

UMA Engineering Ltd.
Engineers, Planners & Surveyors

**UMATAC
INDUSTRIAL
PROCESSES**

**AN INTRODUCTION
AND CREDENTIALS**

UMATAC INDUSTRIAL PROCESSES

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UMATAC INDUSTRIAL PROCESSES

UMATAC INDUSTRIAL PROCESSES

UMATAC Industrial Processes is a specialty services division of UMA Engineering Ltd. which engages in the research, design and development of projects and processes for the extraction and utilization of resources. The Division was formed in 1977 to manage the development of the TACIUK DIRECT THERMAL PROCESSOR, which is a new and alternative process machine for the extraction of bitumen from Alberta oil sands and other hydrocarbon-bearing materials.

A 10 year long program of processor development has been conducted which has included a complete range of research and technical development of both the process and machine from bench scale through pilot plant operational testing, to the design of a demonstration size plant which is one-tenth scale of commercial size.

The PROCESSOR development program has enabled UMATAC to develop skills and facilities in research and engineering which have gained international recognition. Testwork assignments have been conducted on hydrocarbon-bearing materials for clients in other countries, including United States, Malagasy and Australia. The PROCESSOR program is additionally described in a following section.

CONSULTING SERVICES

UMATAC Industrial Processes offers consulting services in basic research, applied research and engineering. Our specialty staff and expertise is well supported by research facilities and equipment, which include the PROCESSOR pilot plant, auxiliary laboratory and bench scale facilities, and computer facilities. UMATAC operates as an integral division of UMA Engineering Ltd., and employs the full scope of the multi-disciplined

engineering capabilities of the other UMA companies and divisions, as appropriate for the assignment.

UMATAC's main interests and capabilities are in the resource fields of:

- petroleum: recovery from oil sands, oil shales, oil spills and oil contaminated properties or dump sites.
- fuels and energy utilization.
- mining and related industrial processes.

Our primary areas of expertise are:

- process: design, development, testing.
- equipment: specification/selection, design, testing and evaluation.
- process plant: design, layout, procurement, construction, operation.
- materials handling systems.
- heat transfer technology.
- combustion technology and equipment design.
- process development and testing leading to final design and establishment of scale-up criteria, including computer modelling.

RESEARCH AND DEVELOPMENT

Over the past 10 years the Alberta Oil Sands Technology and Research Authority has funded the development and testing of a new direct thermal retorting process for the recovery of bitumen from oil sands. This new process was invented by Bill Taciuk of UMATAC Industrial Processes.

More than 12,000 tons of oil sands of various grades have been successfully processed over the past 7 years in a 5 ton/hour pilot plant located in Calgary, Alberta. An impartial evaluation which was done by an

independent consultant to compare the Taciuk process with the commercially practised hot water process showed that the Taciuk process requires less capital investment, provides higher net revenue through increased product yield and will provide an improved rate of return on total project capital investment. Unlike current commercial oil sands plants, the Taciuk process combines the conventional steps of extraction and primary upgrading into one process operation. There are six distinct technical advantages:

- . Consistently high recovery of liquid hydrocarbon from oil sands with bitumen content ranging from 4 to 14 percent by weight.
- . Elimination of upgrader residue.
- . Production of dry tailings, thus eliminating tailing ponds.
- . Elimination of the need for separate extraction and primary upgrading processes.
- . Reduction of process water requirements.
- . Improvement in energy efficiency.

Substantially improved oil yields are projected for oil sands plants using the Taciuk Processor. These yield improvements are the result of a major processing difference: the Taciuk process applies heat directly to the oil sands. All oil in the feed sand is subject to reaction temperatures above 975°F (524°C). At these temperatures, oil thermally cracks, producing coke, light oil and off-gas. The light oil and off-gas are recovered, and most of the coke is consumed as fuel to provide the process heat requirements.

The process is relatively insensitive to oil sands feed grade variation and is not materially influenced by the fines (minerals less than 44 micron in size) contained in the oil sand feed.

Results of the Calgary Pilot project, combined with specific small-scale tests of the Taciuk Processor, have provided valuable direction in determining parameters and methods for scaleup to larger capacities. Confirmation of the scaleup relationships will be made, based on the performance of a proposed 100 ton/hour demonstration facility. The demonstration plant, which is planned to operate continuously over an extended period of time on run-of-mine feed, will also provide confirmation of:

- . Process service factors.
- . Mechanical availability.
- . Process stability and flexibility with changing oil sand feed grade.
- . Optimum operating procedures.

The proposed demonstration program is the detailed design, construction and operation of a 100 ton/hour facility. At this size, scaleup from the present pilot plant processor at 5 tons/hour is 20:1. Subsequent scaleup to the 1,000 tons/hour commercial capacity plant is 10:1. These scale-up ratios meet industry standards for scaling up from the pilot plant to the demonstration plant, and from the demonstration plant to commercial capacities. The location of the demonstration plant and program is the Athabasca Tar Sand area near Fort McMurray.

BATCH TESTING OF CANDIDATE FEED STOCKS

The basic Taciuk Processor technology and mechanical design can be utilized for processing other oil-bearing feedstocks. A small batch unit is available to complete preliminary tests of candidate feed stocks. This data is used to provide approximate design and sizing criteria for initial capital and operating cost projections. Feedstocks that have been tested are as follows:

- low-grade oil sands.
- average and medium-grade oil sands (for base data confirmation)
- high specific gravity bitumen oil sands.
- oil shales from United States.
- Malagasy oil sand/shales.
- Athabasca bitumen.
- oil shales from New Brunswick.
- low-grade oil sand/shale from United States.
- Los Angeles oil-sulphuric acid waste dumps.
- Brazilian oil shales.
- Australian oil shales.
- New Zealand peat bog (scheduled).
- New Mexico low-grade sandstones (possibly schedule)
- Montreal area refinery dump (scheduled).
- treatment of coals (possibly scheduled).
- heavy oil dumps and oil spills (scheduled).
- use as thermal cracker on bitumen (insitu) oils and Lloydminster-type heavy oils (possibly scheduled).
- India refinery dump cleanup (scheduled).

GENERAL ENGINEERING

PROCESSOR DEVELOPMENT

During the past five years, UMATAC has prepared the process design and engineering layout information required for preparation of capital costs and operating cost estimates on the following plant combinations:

- . 100 ton per hour Processor Demonstration plant to be located in the Athabasca Oil Sands.
- . 200 ton per hour Processor Demonstration plant.

- . 1,000 ton per hour Processor plant complete with mining facilities and project infrastructure.
- *. 78 million ton per year multi-line Processor commercial plant.
- *. 22 million ton per year multi-line Processor commercial plant.
- *. 14 unit Processor commercial plant.

NOTE*: Denotes designs and estimates completed for use by independent consultants to evaluate comparative economics for oil sands plants utilizing the Taciuk processor versus plants utilizing the Hot Water - Fluid coking process.

INDUSTRIA'

UMATAC has recently completed the engineering, procurement and construction of a 75 ton per hour limestone and gypsum processing plant. This facility was designed and constructed in 7 months at a cost of 2.5 million dollars. The plant can produce various sized materials in the range of 4 mesh to 325 mesh and has a pelletizing circuit to produce minus 4 mesh agglomerates for use in agriculture for soil pH control.

TACIUK PROCESSOR
HISTORY, OBJECTIVES AND ACHIEVEMENTS.

AN EXCERPT OF A 1985
REPORT AND PRESENTATION
TO THE
AOSTRA BOARD OF DIRECTORS

2.0 TACIUK PROCESSOR CURRENT HISTORY, OBJECTIVES AND ACHIEVEMENTS

2.1 INTRODUCTION

The TACIUK DIRECT THERMAL PROCESSOR has been under research and development since late 1974 in Calgary, Alberta, Canada. This work has been carried out by the UMATAC Industrial Processes Division of Underwood McLellan Limited, Consulting Engineers and, since 1977, under funding agreements with the Alberta Oil Sands Technology and Research Authority (AOSTRA).

Original research work and small scale testing was completed by 1977 when the original financing agreement for Phases A and B, covering pilot plant construction and testing, was signed with AOSTRA. Under this agreement a pilot plant was constructed in 1977-78, and was operated for a period of four and one half (4½) years using the following feed stocks:

- 1) Heavy Oil Atmospheric Tower Bottoms from Local Refineries.

The Processor was initially tested as a coker using heavy oil bottoms and Lloydminster oil.

- 2) Heavy Oil from Lloydminster Field
- 3) Athabasca Oil Sands

low grade	-	6% oil content
medium low grade	-	9% oil content
average grade	-	11-13% oil content
high grade	-	+13% oil content

- 4) U.S. Semi Consolidated Sand-Shale

low grade	-	6% oil content
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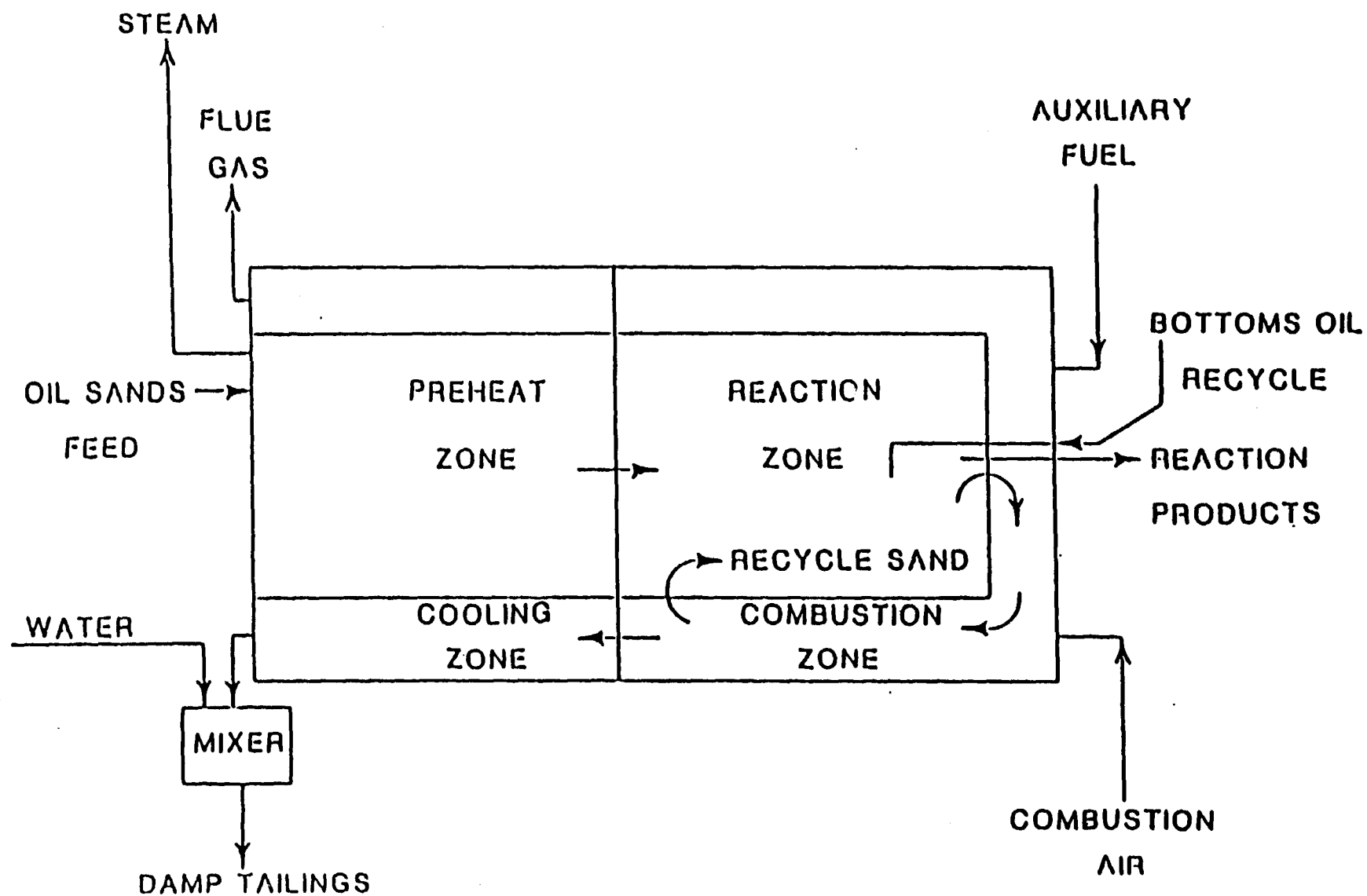
During 1982 the Pilot Plant was operated on several extended runs to test performance on oil sands varying from low grade to high grade. These runs provided confirmation data, also product oil samples which were analyzed in detail and formed the basis for hydrotreating requirement projections.

In December, 1982 UMATAC received approval for Phase I of the Demonstration Plant program. The primary objectives set out for this phase were to establish a processor plant design and cost basis suitable for commercial plant comparative cost studies, provide a definitive design and cost basis for the demonstration plant, and to carry out pilot plant operations, as required, to provide additional confirmation for processor design purposes. These objectives have now been achieved.

2.2 PROCESSOR DESCRIPTION

The Taciuk Processor consists of a horizontal rotating vessel containing compartments which house individual process steps. Figure 2.2A schematically shows the arrangement and process flows. As-mined oil sand feed is introduced into the preheating section of the processor where connate water is evaporated as steam, frozen material is ablated, oversize is removed and the oil sand is heated by heat exchange with the hot outgoing tailings sand. The heated oil sand is then transported into the reaction zone and mixed with hot sand from the combustion zone. The resulting temperature is adequate to thermally crack the hydrocarbons yielding a vapor stream containing the cracked reaction gases and liquids (in vapor form), and a coke residue coating on the sand. The vapor stream is passed through cyclones to remove fine solids and then enters a fractionating tower where various liquid fractions are separated for further processing. The vapor stream then passes to a light ends plant for light hydrocarbon liquid recovery and gas desulfurization.

The coke coated sand discharges from the reaction zone to the combustion zone where preheated air is injected to burn most of the coke. Auxiliary burners provide heat for startup and trim control. The hot sand from the combustion zones passes through a recycling arrangement that ensures an adequate supply of heat to the reaction zone, while allowing net sand to move into the cooling zone. In the coking zone, the sand and combustion gases are cooled by heat exchange with the incoming oil sand. The partially cooled sand leaving the cooling zone is removed from the processor, further cooled and dampened by water



TACIUK PROCESSOR
(PILOT PLANT)

FIGURE 2.2A

addition, and transported by conveyors to the tailings disposal area. Combustion gases are removed from the processor, then through a cyclone to reduce the fine solids content, and then through a wet scrubber. The scrubber removes most of the remaining fine solids and chemically removes most of the sulfur dioxide produced by the combustion of coke. Scrubber solids are disposed of by using the scrubber liquid as a cooling medium for the tailings sand.

2.3 PHASES A AND B HISTORIES (1977 TO 1982)

The Pilot Plant construction was completed in June, 1978. During the operating periods of each year the following processor runs or performance-check days were completed. Test runs were normally scheduled for 6 to 16 hours depending on the specific test requirements. Extended runs usually covered a period of two to five days.

1978-1979-1980 (Phase A)

	Runs
Reduced Crude	- 41
Oil Sand	- 63
Heat Exchange	- 17
Coke Combustion	- 15
Misc. Mechanical	- <u>42</u>
TOTAL	178 runs

1981 (Phase B)

Reduced Crude	- 16
Utah Oil Sands	- 3
Extended Run 1	- 46 hour duration
Extended Run 2	- 75 hour duration
Extended Run 3	- 49 hour duration
Misc. Oil Sand	- 20
Misc. Other	- <u>21</u>
TOTAL	63 runs

1982 (Phase B)

Total Runs	- 32 including:
Extended Run 1	- 82 hour duration
Extended Run 2	- 106 hour duration
Extended Run 3	- 73 hour duration

Extended Run 4	- 106 hour duration
Extended Run 5	- 27 hour duration
Extended Run 6	- 57 hour duration

2.3.1 Phase A History

Following is a summary of key time periods prior to 1981:

1974-75:	Original research and conceptual design.
1976-77:	Continued research and design while negotiating with AOSTRA for financing of pilot project.
July/77:	Signed agreement with AOSTRA.
June/78:	Completed Pilot Plant construction.
July/78-Mar/79:	Mechanical and thermal runs on Processor using reduced crude feeds.
Mar-June/79:	Initial runs on oil sands.
Jul-Sept/79:	Fractionating tower modifications.
Sept-Dec/79:	Oil sand runs at 4 to 5 tons/hour with marginal coke combustion.
Jan-Apr/80:	A complete review of oil sand runs was completed and a summary report prepared. - Conceptual design and cost estimates for a Demonstration Plant and Commercial Plant were completed. - Associated Pullman-Kellogg, consulting engineers, verified estimates and prepared a comparison study of a Taciuk Processor Plant against a Syncrude type plant.
Dec/79-Apr/80:	Coke combustion research, redesign and reconstruction of combustion zone of Processor.
Apr-Dec/80:	Reduced crude and oil sands runs. Coke combustion increased to 30-60%.

The 1980 runs produced a more acceptable oil product and a higher liquid yield. This was due to improvements in seals around the reaction zone and improvements in measurement and analysis of gas streams.

2.3.2 Phase B History

Phase B of the initial development program was approved in early 1980 and carried through until November of 1982. Its primary goals were to improve processor oil yield, provide better oil feed to "sum of product" closures, and to prepare for consultive participants.

1981 Operations

The 1980-1981 winter plant program concentrated on improving sampling reliability by purchase of a gas chromatograph and installation of an off-

gas and flue gas sampling, cleaning, and delivery system.

The combustion zone was slightly modified, as were various seals. Bottoms oil and side draw oil handling systems were installed.

- Dec/80-Apr/81: - Review of overall run data, modification. Emphasis placed on flue gas and off-gas samples and analysis systems to improve closures.
- Feb-June/81: - The "Confidential Technical Disclosure Document" was written.
- May-July/81: - Increased manpower in technical and operative areas. A series of 10 runs on reduced crude completed and demonstrated measurement and analysis accuracy for closure of mass balances.
- April/81: Disclosure meeting with Industry to obtain Consultive Participants.
- Sept-Dec/81: Three extended runs were only partially completed due to a mechanical problem in the processor.
- Nov-Dec/81: Assessment of equipment and review of modification alternatives to improve processor seal performance and coke combustion capacity.

1982 Operations

During the first 4 1/2 months of 1982 a major program of Pilot Plant improvements and maintenance was completed. The Processor unit was modified to incorporate design changes that would closely resemble the proposed Demonstration Plant Processor.

Processor alterations included:

- 1) Modification of reaction zone and combustion zone.
- 2) Installation of improved seals around reaction zone.
- 3) Improved control of internal sand flow and bed levels.
- 4) Addition of a preheat steaming zone.
- 5) Internal shell mechanical support structure.

Auxiliary system maintenance and alterations was completed to improve system reliability.

The purpose of these changes was to improve the plant's operational and

process performance for the 1982 season.

The primary objective of the 1982 pilot plant testing program was to demonstrate the capability of the Taciuk Processor and auxiliary systems to run for continuous periods of up to four days with stable plant and process operation.

The detailed objectives of the 1982 pilot plant operating program were as follows:

- 1) Complete five scheduled runs of three to four days duration using a range of oil sands feed grades.
- 2) Complete other tests to confirm process relationships, particularly noting impact of the 1981-82 modifications.
- 3) Study scrubber efficiency and chemistry.
- 4) Study effects of O₂ contamination on heat exchange and oil product quality.
- 5) Study preheat steam condensing, handling, and separation problems.
- 6) Maximize coke combustion.
- 7) Provide run samples and data for Consultive Participants.
- 8) Optimize run conditions to maximize liquid yield of an acceptable oil and off-gas product. Practice bottoms oil recycle.
- 9) Provide oil samples for use in analyzing downstream treating and refining requirements.
- 10) Provide additional scale-up data.
- 11) Carry out a complete inspection of the processor and all related equipment after each run.

The 1982 operating period started off with a series of mechanical runs. Approximately 10 runs of two-shift duration, using various oil sands grade feed stocks, were completed.

The main thrust of the program was the extended run schedule. This was completed as follows:

- | | |
|---------|--|
| July 6 | - Extended Run No. 1 using 12% grade oil sands obtained from Suncor in the fall of 1981. |
| | Window Run Length - 76 hours |
| | Feed Consumed - 300 tons |
| | Average Feed Rate - 3.9 T/hr. |
| July 26 | - Extended Run No. 2 using 6 to 8% grade oil sands obtained from Suncor in June, 1982. |
| | Window Run Length - 100 hours |
| | Feed Consumed - 460 tons |
| | Average Feed Rate - 4.6 T/hr. |

- Sept. 7
- Extended Run No. 3 - shorter run using available 14% grade oil sands obtained from Suncor in August, 1982.
 - Window Run Length - 47 hours (reactor zone plug - interruption of 19 hours)
 - Feed Consumed - 300 tons
 - Average Feed rate - 4.0 T/hr.
- Sept. 20
- Extended Run No. 4 - Using 10% grade oil sands obtained from Suncor in late 1981.
 - Window Run Length - 94 hours (5 hours to repair tailings screw conveyor)
 - Feed Consumed - 450 Tons
 - Average Feed Rate - 4.0 T/hr.
- Oct. 4
- Planned 2 1/2 day run -
Terminated due to mechanical failure of thermocouple assembly and sensor tubes.
- Oct. 20
- Planned 2 day run at higher feed rates using 12% Suncor oil sand feed. (4 hour interruption to repair screw conveyor).
 - Window Run Length - 44 hours
 - Feed Consumed - 250 tons
 - Average Feed Rate - 5.9 T/hr.
- Oct. 29
- 12 hour run on 5% low grade Syncrude oil sands obtained in 1978.

During August and September the Gulf Oil laboratory in Toronto completed detailed oil product analyses from Extended Runs 1 and 2. These analyses showed only negligible differences in quality of oil obtained from the 6-8% and 12-13% oil sand feeds.

The results also indicated that the hydrotreating requirements for these Processor oils are very similar to requirements for Fluid Coker oils.

2.4 PHASES A AND B ACHIEVEMENTS

During the five years spanned by Phases A and B, UMATAC's staff made every possible effort to successfully overcome the various technical, equipment, process, measurement and analyzing problems that have

arisen as a result of Pilot Plant operations. The Technical Committee and Management Committee structure were of major benefit in specific areas. UMATAC has designed and carried out specific research programs in order to obtain a detailed understanding of various process related phenomena such as coke combustion, heat exchange, and effects of air contamination on oil sands and products obtained from thermal cracking. Results obtained from these R&D programs have been used to design and implement modifications to the pilot plant equipment to improve performance and/or measurement accuracy.

By the end of 1982 UMATAC had achieved the following:

1. Demonstrated the Taciuk processor system's overall capabilities at the Pilot Plant Phase. These capabilities are:
 - a) ability to produce an acceptable oil product for hydrotreating by use of bottoms oil wash to remove intrained fine solids. Then to recycle this bottoms oil back to the processor.
 - b) ability to produce consistent yield structures.
 - c) ability to operate safely during periods of upsets.
 - d) ability to produce an off-gas with less than 30% dilution by combustion gases and having a Btu value of over 700 Btu/cu.ft.
 - e) ability to burn up to 82% of available coke to provide a large percentage of the process heat requirements.
 - f) ability to use internal Processor heat exchange to improve the heat efficiency of the process.
 - g) ability to provide consistently high oil recoveries over a range of oil sands feeds covering from 3% to 15% oil content.
 - h) ability to rapidly recover from a reactor plug.
 - i) ability to produce a material balance and thermal balance with closures of $\pm 2\%$ on extended runs.
2. Umatac has processed and obtained results from the Pilot Plant for:
 - a) 1200 tons of 9% Syncrude oil sands.
 - b) 2500 tons of 11-13% Suncor oil sands.
 - c) 200 tons of 14% Syncrude-Suncor oil sands.
 - d) 500 tons of 6-7% Suncor oil sands.
 - e) 250 tons of 5-6% Syncrude oil sands.
 - f) 600 tons of 8-10% Suncor oil sands.
 - g) approximately 1000 barrels of reduced crude.
 - h) approximately 150 barrels of Lloydminster crude.
 - i) 30 tons of 8% Utah oil sand.
 - j) 50 tons of 3% Syncrude oil sands.
3. Processed and obtained yield results from the 1 foot by 3 feet batch test unit for:

- a) oil sands samples at different conditions.
 - b) 250 lbs. of Madagascar consolidated oil sands.
 - c) 200 lbs. of Utah oil sand.
 - d) 200 lbs. of Tosco high grade oil shale samples.
 - e) 300 lbs. of Asphalt Ridge oil sands.
4. Established a working relationship with the Consultive Participants.
 5. Obtained data on operational problems related to buildups, erosion, etc. Future designs would attempt to eliminate these areas or provide for easy access and/or "on the run" means of clearing any troublesome areas.
 6. Obtained the technical and practical background necessary to carry on with a demonstrator plant or initial commercial small scale plant for certain applications.
 7. Developed computer models of process phenomena. Refinements are to be made, as required, by use of supplementary research programs, paper studies and special tests on the pilot plant processor or batch units.
 8. Completed initial capital and operating cost estimates and conceptual design for larger processors with capacities of 200 and 1000 Ton/hr.
 9. Trained a nucleus staff for research, operation, and design duties.

2.4.1 Consultive Participants

In April of 1981 UMATAC/AOSTRA invited Oil Industry representatives to a disclosure session where the details of a "Consultive Participant" package were released. Two participants, Gulf Canada Resources Ltd., and Canstar Oil Sands Ltd., signed secrecy agreements by the end of 1981 and attended their first Technical Committee meeting in February, 1982.

Discussions with the participants regarding their testing and data requirements made several revisions necessary to the 1982 operating program.

These revisions were:

- 1) A requirement for low grade oil sands tests over and above those scheduled by UMATAC.
- 2) Additional sampling and analysis of some process streams.
- 3) Gulf Oil presented a proposal for product oil testing to include full characterization tests on a series of oil samples and prediction of hydrotreatment requirements.

The consultive participants asked that more emphasis be placed on

runs using low grade oil sands. As a result of this, 1200 tons of low grade oil sands were obtained from Suncor. The tonnage was split to obtain 600 tons of a mixture of average grade which was diluted with pit waste material, and 600 tons of true low grade oil sand of 6 to 7% oil content. These low grade materials were tested in the plant during 1982.

Gulf Canada Resources Ltd. completed detailed oil analyses on five (5) samples of UMATAC product oil, and provided estimates of the hydro-treating requirements necessary to produce an acceptable synthetic crude.

Gulf's local laboratory was used to provide oil sands feed analyses for all feed samples during the 1982 and 1983 operating seasons.

2.5 PHASE I DEMONSTRATION PROJECT HISTORY (1983-1984)

On November 24, 1982, a joint AOSTRA/UMATAC presentation was made to the AOSTRA Board, in which it was recommended that the AOSTRA/UMATAC Project, for the development of the Taciuk Processor, proceed to the first phase of a two-phase program to construct and operate a large scale field demonstration of the Processor. The first phase of the program would provide the necessary information to allow the Authority to decide whether or not to proceed with construction and operation in Phase II. This recommendation was approved by the Authority early in December, 1982.

The fundamental objectives of Phase I were to:

1. Carry out the process design and sufficient detailed engineering to develop a definitive estimate for a 200 ton per hour Demonstration Plant to be constructed and operated in the Athabasca region.
2. Prepare an updated conceptual design and cost estimates for a commercial scale Taciuk Processor and carry out a comprehensive comparative economic evaluation.
3. Operate the existing pilot plant as necessary to provide additional data, as required, for design purposes.
4. Endeavour to maintain the existing consultive participation and solicit additional industry participation in Phase I.

These objectives have been completed. During the course of Phase I execution a number of significant program changes have occurred and the following summary reviews the Phase I modified program.

1. Preliminary capital and operating cost estimates were prepared for a 200 ton per hour Demonstration Plant in September, 1983. Including charges for oil sands feed supply and services to be provided from the Oil Sands Demonstration Centre (OSDC), the total cost (capital and operating) was estimated to be in the range of \$100-110 million.

This estimate was substantially higher than was anticipated, therefore, it was agreed that the design capacity should be reduced to 100 tons per hour. This reduced capacity was considered to be the minimum for an adequate demonstration of the Processor. The redesign and the definitive estimates were completed in May, 1984.

2. A design data book has been prepared for commercial scale plants having design oil sands feed capacities of 78 million tons per year and 22 million tons per year equivalent to 110,000 and 30,000 Bbl/day respectively. Capital and operating cost estimates for the processor area of these plants are completed. This information was passed to Partec Lavalin, the Comparison Study Contractor, and forms the basis for a comparative evaluation. The Lavalin final report is scheduled for completion in early August, 1984.
3. The pilot plant was operated during the period between May and November, 1983. These operations were primarily directed at:
 - a) developing scaleup relationships for preheater heat exchange mechanism and testing of extended surface configurations. As a result of this investigation, which demonstrated that the overall heat transfer coefficient was not a variable, an innovative multi-tube preheater design has been developed to provide greater transfer surface within a given kiln length.
 - b) elimination of coke buildup in the reaction zone due to fractionator bottom recycle, and of coke deposition in the vapor product transfer line.
 - c) reduction of inerts in the Processor off-gas hydrocarbon vapor due to combustion gas inflow.
 - d) improving operation of the flue gas clean-up system.
4. The Phase B final Summary Report and Technical Update Document was completed in early 1983.
5. The 1983 Pilot Plant Operations Summary Document was released in May, 1984.

During the 1983-84 winter period R&D test units were constructed to provide scaleup data for Demonstration and Commercial unit designs.

These were as follows:

- 1) Major heat exchange test program to test several shapes and sizes of corrugated tubes. This program was to establish the best shape design to be used in the demonstration plant, and to establish the diameter effect when scaling from the demonstration size to the commercial size.
- 2) Major stress-strain test apparatus encompassing a fabricated riding ring and a dual rubber tire drive. The stress part of the program has been completed and the long range tire wear tests will be carried out during the next one to two years.
- 3) Horizontal displacement patterns for vertically falling sand streams have been studied in two models and in pilot plant related test work.

2.5.1 Consultive Participants

Canstar Oil Sands Ltd. has been a consultive participant in Phase I. Gulf Canada Resources, who participated in the previous phase, declined to join the current program. Gulf's decision not to participate appears to have been a result of their reduced emphasis on mineable oil sands development.

2.5.2 Testwork and Contacts for Outside Applications

During 1983 UMATAC provided background information to, and carried out testwork for, other interested parties. These were as follows:

- 1) Batch testwork on low grade Brazilian oil shale fines. A report was submitted to Mr. R. Humphries and an additional sample has been received from Brazil.
- 2) A 600 ton sample of consolidated oil sand has been received from Madagascar. This sample will be tested during June and July, 1984.
- 3) Further batch testwork on Utah oil shales was carried out as comparison for the work done in 1) above.
- 4) A sample of oil sands from Israel has been received at the Pilot Plant and is scheduled for batch testing.
- 5) Information regarding Taciuk Processor application was sent to several companies as a result of inquiries.
 - a) Husky Oil and Imperial Oil inquired about use of the processor

for cleanup of sand contaminated by oil spills and cleanup of site related dump ponds.

- b) Standard Oil of Ohio in Cleveland inquired about use of the processor on oil sands and shales.
- c) Phillips Petroleum from Bartlesville, Oklahoma inquired regarding use of the processor for a 10,000 bbl/day oil sands operation.

2.6 PHASE I - DEMONSTRATION PROJECT ACHIEVEMENTS

The significant achievements for Phase I fall into four categories as follows:

A. Plant designs and estimates.

The following items were completed in this category.

- 1) 200 ton per hour Demonstration Plant preliminary design and estimate. After review, the decision was made to reduce plant size to be a minimum of 100 tons per hour.
- 2) 100 ton per hour Demonstration Plant basic design and cost estimate. This forms the basis for the present Phase II submission.
- 3) 1000 ton per hour commercial Processor preliminary designs and balances to a level suitable for forming the basis of Partec Lavalin plant comparison studies.
- 4) Completion of Commercial Plant design and cost estimate for input to the Dynawest study commissioned by ERCB. Results from this study indicated economic and environmental improvements for future oil sands plants utilizing the Taciuk Processor.
- 5) Completion of Commercial Plant capital and operating cost estimates.
- 6) Completion by UMATAC of capital and operating cost estimates for comparing Processor and Hot Water - Fluid Coker plants. This data was used by UMATAC to prepare a relative cost comparisons and sensitivity analysis.

B. Pilot Plant Operations

The Pilot Plant was in operation for 205 hours on oil sand and 280 hours on tailings sand during 1983 with the following achievements.

- 1) The heat exchange area available to the incoming oil sand was increased by adding corrugations to the preheat shell. Approxi-

mately 40% of the operating season was spent fabricating and installing corrugated spiral test sections. The area was increased in stages of 8, 21.2, and 33.5% above the initial cylindrical area. The quantity of heat transferred increased in proportion to the increase in surface area provided by the corrugation.

- 2) Demonstrated the ability to recycle bottoms oil back to the reaction zone for cracking without excessive coke buildup. A series of modifications were tested and the combination of change of spray location, use of steam as a carrier, and closer control of the recycle flow enabled Processor operation for extended periods without significant coke buildups.
- 3) Minimized fractionating tower entrance coke buildup. Several modifications such as entry point alterations and heat tracing reduced the tendency for such buildups. This is a common operating problem in all heavy oil refineries.
- 4) Minimized the internal heat exchange fouling. Attention to operating upset conditions and the mechanical internal modifications assisted in minimizing buildups.
- 5) Studied flue gas scrubber fouling and buildups. An internal change to the UMATAC scrubber improved the SO₂ removal efficiency to acceptable levels but a degree of buildup in pumps and pipelines was still present.
- 6) Demonstrated emergency shutdown safety. In October a sudden shutdown was induced while the Processor was operating on oil sands. The cooldown was achieved safely. Examination after cooldown showed no presence of hard deposits in the preheat zone or reaction zone. The preheat zone contained lightly consolidated deposits which were removed by ten minutes of Processor rotation at ambient temperature.

During the final extended oil sands run, an electrical power failure of 1½ hours duration occurred. After power was re-established, the processor was put back on line and operated on oil sands within fifteen minutes. No detrimental conditions were found as a result of this power failure.

- 7) Improved off-gas purity was demonstrated during several runs. Operating conditions were varied to achieve less off-gas dilution from with inert gases such as N₂, CO₂ and CO which originate in the combustion zone.

Final analysis of 1983 oil sands run data was completed in May, 1984. The results agreed closely with the 1981-1982 Phase B summary results.

C. Processor Design Development

Processor size and weight are largely influenced by the heat exchange zone and by the large riding rings and rollers. Scaleup based on a single tube heat exchange resulted in excessive processor lengths. For this reason UMATAC's 1983 research and operating efforts were concentrated in the heat exchange area. During the summer of 1983, a major design change in the heat exchange was developed. This design change is predicated on the use of five parallel flow tubes instead of a large single tube. A spiral corrugation of these tubes further increases the surface area available per foot of processor length. This design results in a shorter and less costly Processor.

During the last half of 1983 the concept of using rubber tires and fabricated sectional riding rings in place of the conventional solid steel riding rings, rollers and gear drives was investigated. The concept proved feasible and a summary report and recommendations to change process designs to this concept was submitted to the Management Committee in December, 1983. The potential capital cost saving for a commercial processor by use of rubber tires was estimated at five to seven million dollars each. Eleven Processors are required for a 110,000 Bbl/day operation which results in total savings of 70 million dollars.

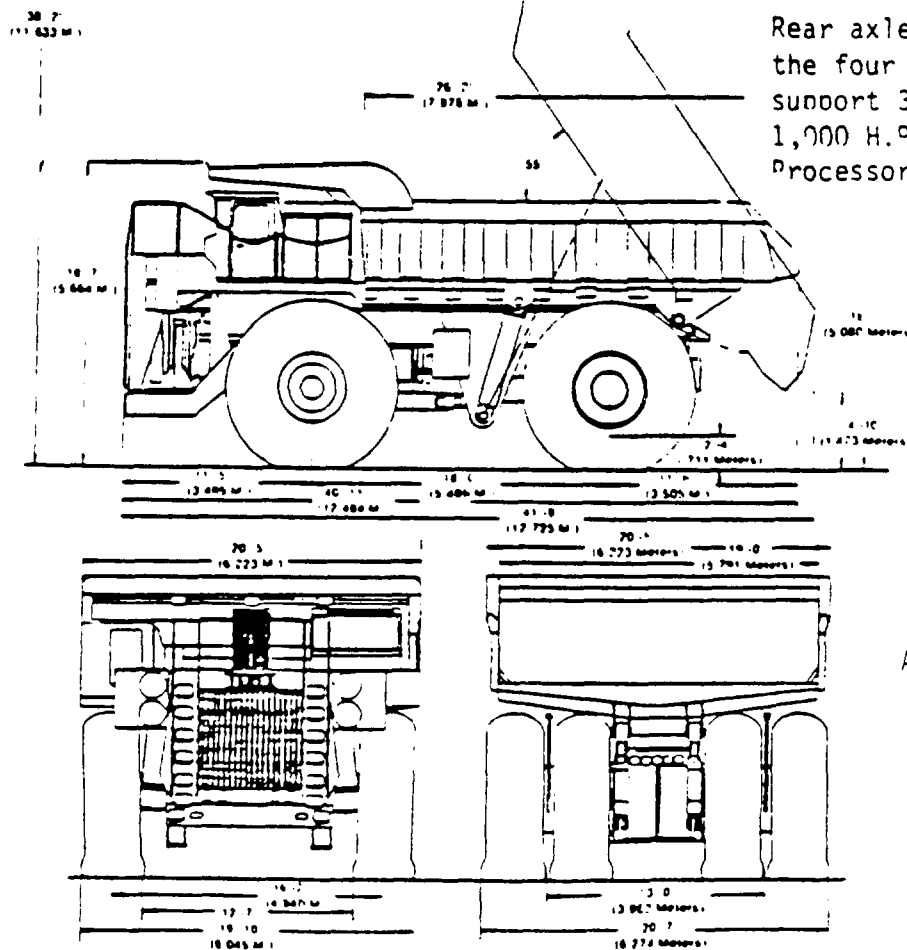
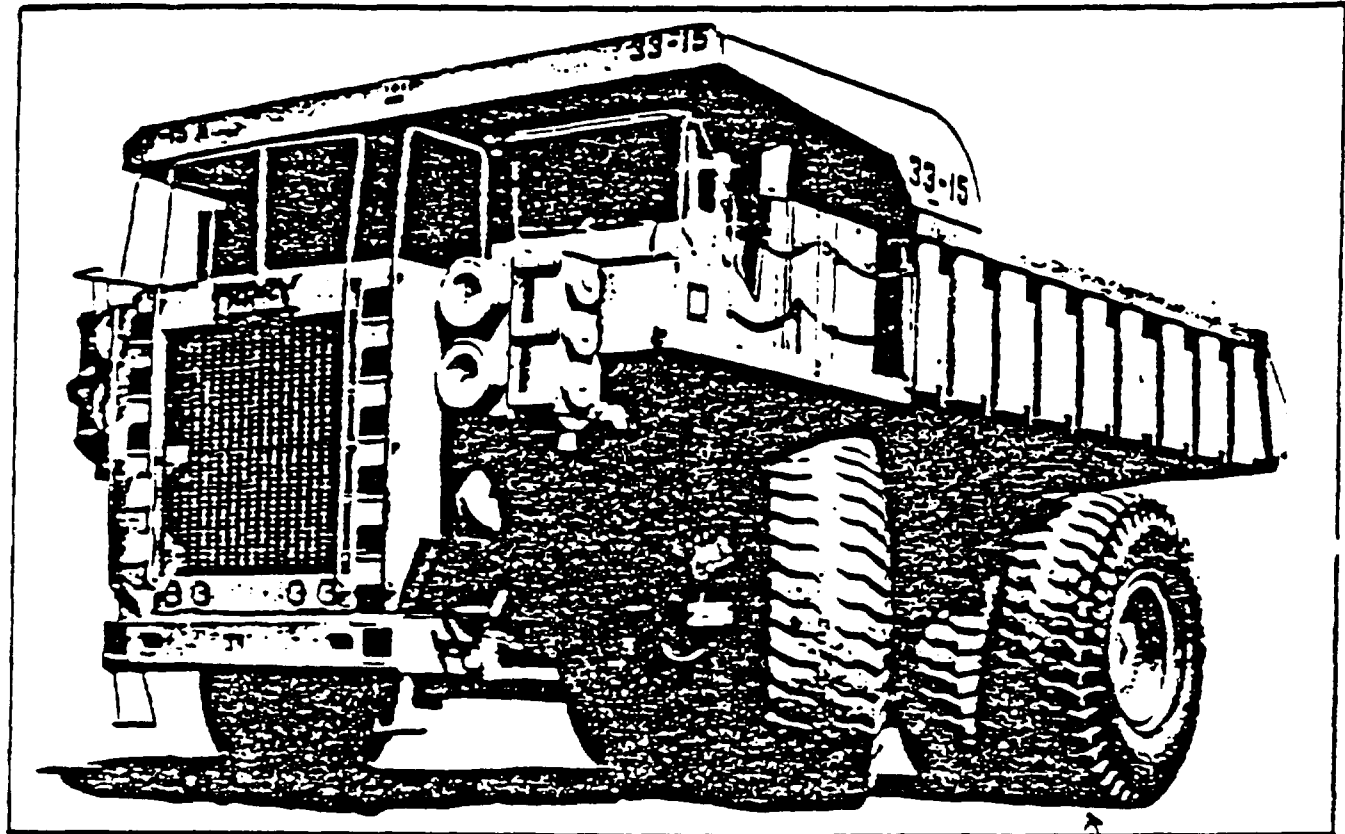
In December UMATAC received Management Committee approval for use of the five tube spiral corrugated heat exchange arrangement and the tire support and drive assemblies for the Processor.

During early 1984 the 100 t/h Demonstration Processor and the 1000 t/h Commercial Processor were redesigned using the above described concepts. Design details and cost estimates were prepared and are used for the Phase II Cost Estimates and the Comparison Study estimates.

Attachment 2.6.1 illustrates a typical truck which uses the rear axle assembly chosen for Processor support and drive requirements.

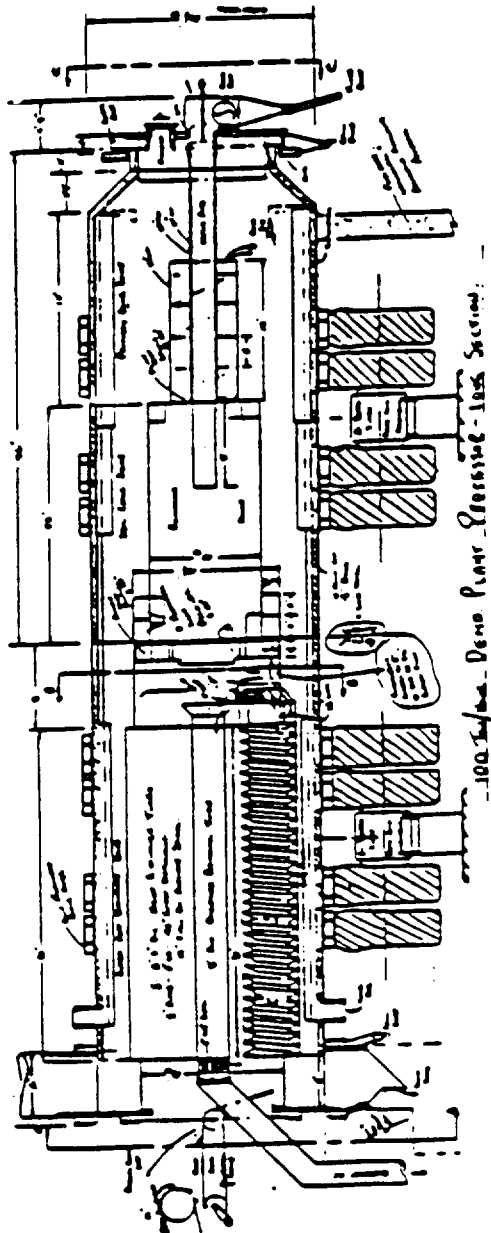
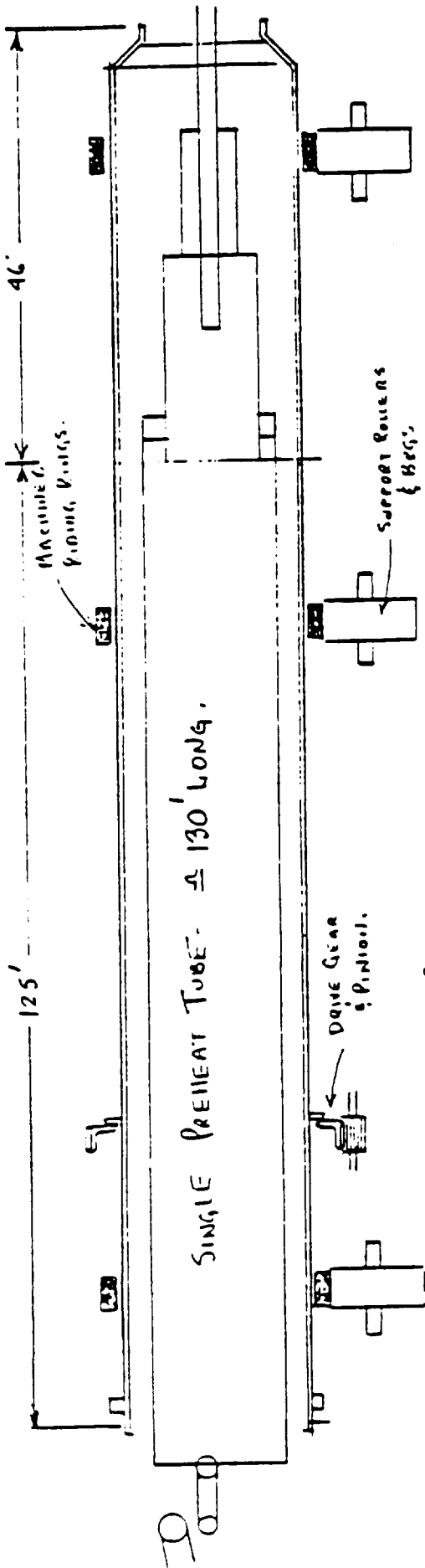


GENERAL INFORMATION



Rear axle assembly with the four tires used to support 320 tons and provide 1,000 H.P. of propulsion to Processor.

ATT: 2.6.1



1984 DESIGN WITH 5 PARALLEL FEED CORRUGATED TUBES
AND TRUCK REAR END SUPPORT & PROPULSION.

ATT. 2.6.2
2.15b

Attachment 2.6.2 illustrates the relative Processor designs utilizing a single cylindrical tube, and 5 parallel - spiral corrugated tubes.

The combination of processor design improvements that have occurred during Phase I can be summarized by the relative capital cost reductions for a 1000 ton/hour unit.

Dynawest Study Costs (single-tube heat exchange and steel riding rings, etc.)	Design & Fabric	- 24.0 million
	Erection	- <u>6.5 million</u>
	TOTAL	30.5 million
Latest Estimate (five-tube heat exchange and rubber tire drive & supports)	Design & Fabric	- 17.5 million
	Erection	- <u>4.9 million</u>
	TOTAL	22.4 million

This represents a saving of 8.1 million dollars per unit for a 26.6% cost reduction.

D. Special Testwork

A number of significant test programs were carried out during Phase I. These programs were necessary to obtain a full understanding of the heat exchange phenomena, the horizontal trajectories of falling sand streams and to verify the mechanical design considerations for a concentric tube suspension system, fabricated riding rings and use of rubber tire drive and support systems. These programs were added to the Phase I scope after approval of the base program.

1) Heat Exchange Test Program

A series of tests were conducted on small test apparatus in early 1983 to obtain a better understanding of influencing parameters but the relationships differed for each apparatus. During July, 1983 the decision was made to conduct a major program during the winter of

1983-84 using five foot and nine foot diameter tubes containing three different shell configurations. Approximately 75% of this test work has been completed to date and the remaining work is scheduled for completion in late 1984. Tests to date have provided confirmation data with regard to the Demonstration Plant and Commercial Plant heat exchange design.

2) Stress-Strain Apparatus

In December, 1983 the decision was made to construct a $\frac{1}{2}$ scale processor outer shell structure including fabricated riding ring and tires for drive and support. The stress-strain portion of the program has been completed and is currently being reviewed and studied to determine the impact on processor mechanical design. The tests have indicated that the stress levels imposed by the fabricated support rings and tire structures are well within present demonstration and commercial designs.

The tire wear and thermal resistance tests will be carried out during the remainder of 1984. These tests will provide data on the best selection of rubber compounds to maximize tire life.

3) Horizontal Sand Trajectories

Tests were conducted on two test apparatus during early 1984 to study the rate of horizontal transport of sand falling through a horizontally moving air stream. Results show that the Demonstration Processor design is stable with respect to sand/air velocities. The Commercial Processor design is adequate although test results to date indicate that some excessive sand transport may be experienced. Additional test work is scheduled to verify the Commercial design.

2.7 FINANCIAL SUMMARY - DEVELOPMENT TO DATE

The initial funding agreement was signed with AOSTRA in June, 1977. Since that time UMATAC has progressed through three phases of development as discussed in earlier sections. Following is a summary of project expenditures incurred during these development phases.

Phase A - Pilot Plant

1977 - Project Construction Costs	\$943,000
1978 - UMATAC Operating Costs	480,000
1979 - UMATAC Operating Costs	711,000
1980 - UMATAC Operating Costs	<u>710,000</u>
Sub Total	\$2,844,000

Phase B - Pilot Plant

1981 - UMATAC Operating Costs	1,300,000
1982 - UMATAC Operating Costs	<u>1,324,000</u>
Sub Total	\$2,624,000

Approved for Phases A and B \$5,350,000

Phase I - Demonstration Plant (also Pilot Plant)

1983 - UMATAC Operating Costs	\$2,280,000
1984 - UMATAC Operating Costs (To June 30)	1,600,000
1982 - Phase B Overrun	118,000
Comparison Study Estimate	350,000
Allocation for Hydrotreating Tests	<u>300,000</u>
Sub Total	\$4,648,000
Approval for Phase I	5,800,000

During the seven year period since 1977 UMATAC has incurred expenditures totaling 9.7 million dollars in the development of the Taciuk Processor and its Associated Systems. The approved expenditures for Phase I will be expended in early July, 1984. All of the major objectives will have been achieved by that date.

2.8 PROCESSOR PERFORMANCE, OIL YIELD, AND OIL QUALITY SUMMARY

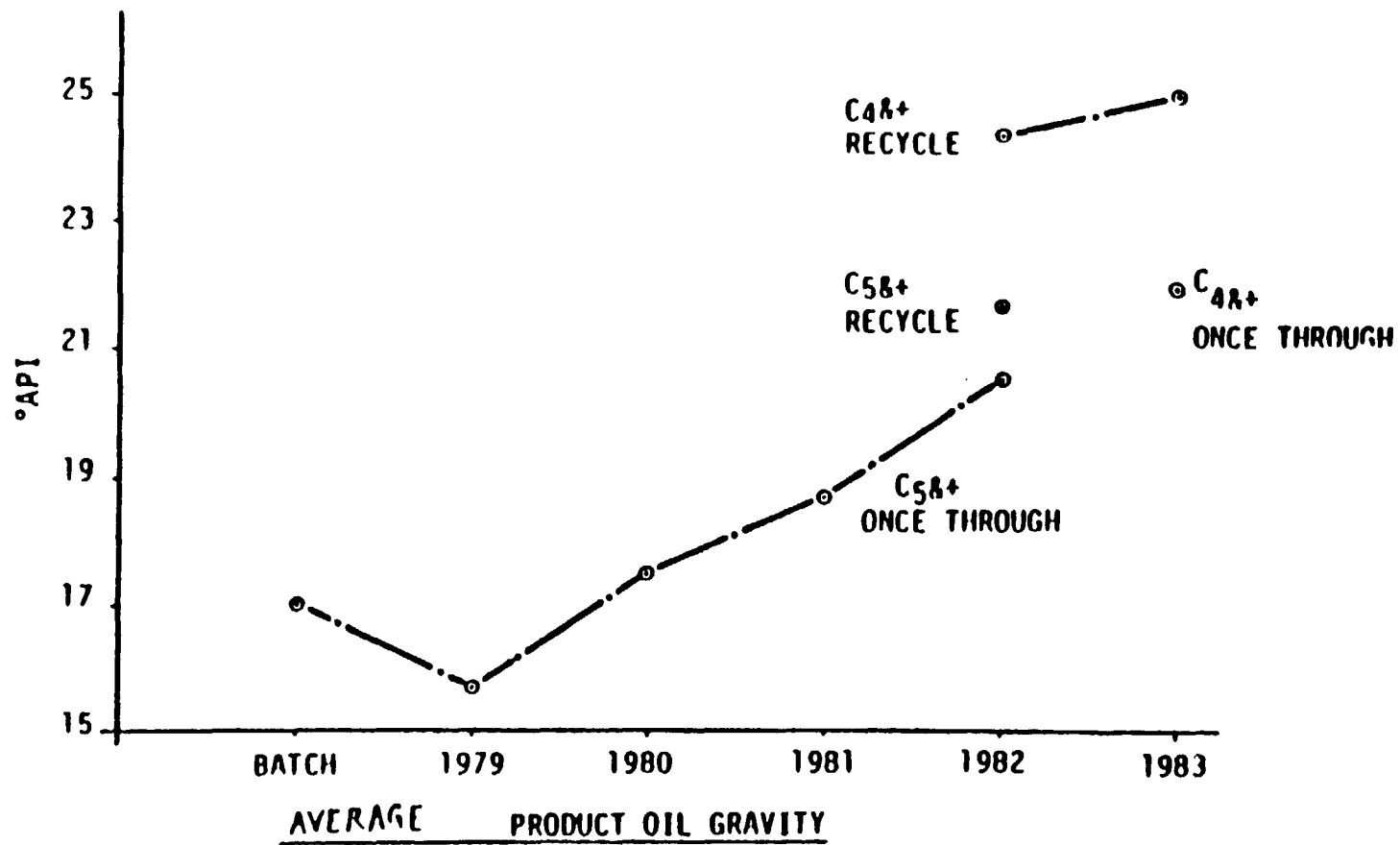
UMATAC's year-by-year improvement in key process areas can best be summarized by use of graphs. These are presented as follows:

- Graph 2.8.1 Product Oil Gravity
- Graph 2.8.2 Off-Gas Dilution With Combustion Gases (Seals)
- Graph 2.8.3 Coke Combustion Capacity
- Graph 2.8.4 Heat Transfer

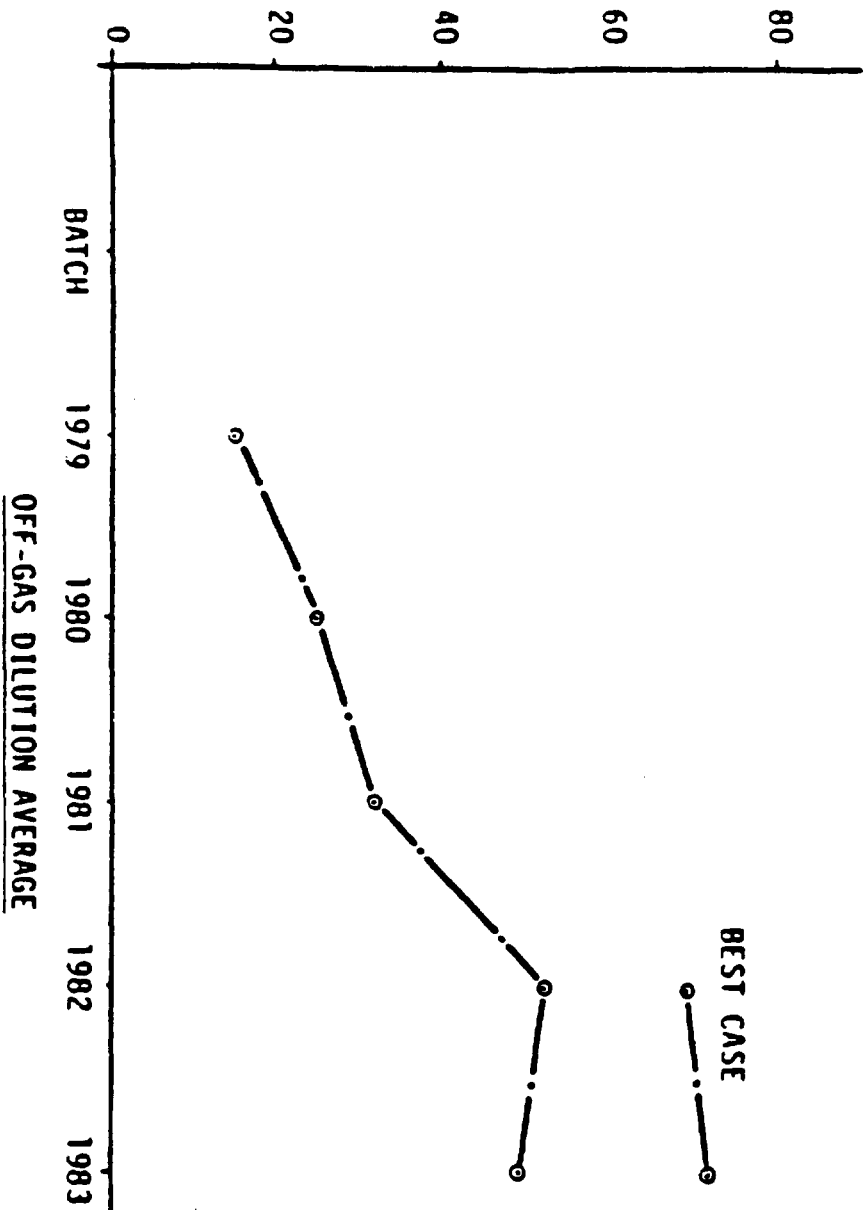
Note that the curves have generally indicated similar results for the last two years of operation indicating a plateau in improvements due to testing in the pilot zone.

2.8.1 Processor Product Yields and Recoveries with Variable Feed Grades

During 1982 extended runs were completed on four grades of oil sands. The following table illustrates the yield patterns actually obtained while operating under similar process conditions.



HYDROCARBON % IN OFF-GAS



OFF-GAS DILUTION AVERAGE

BATCH

1979

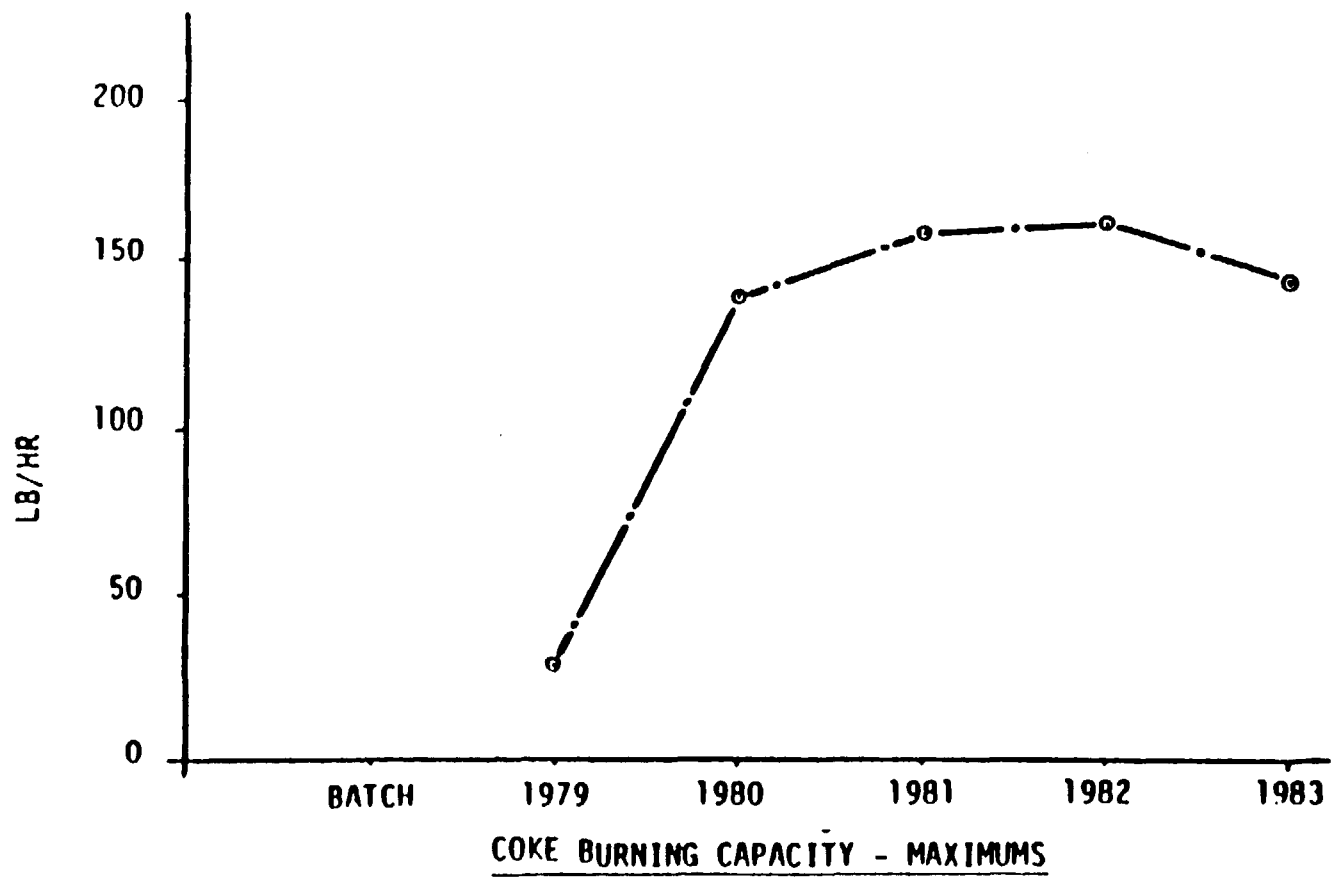
1980

1981

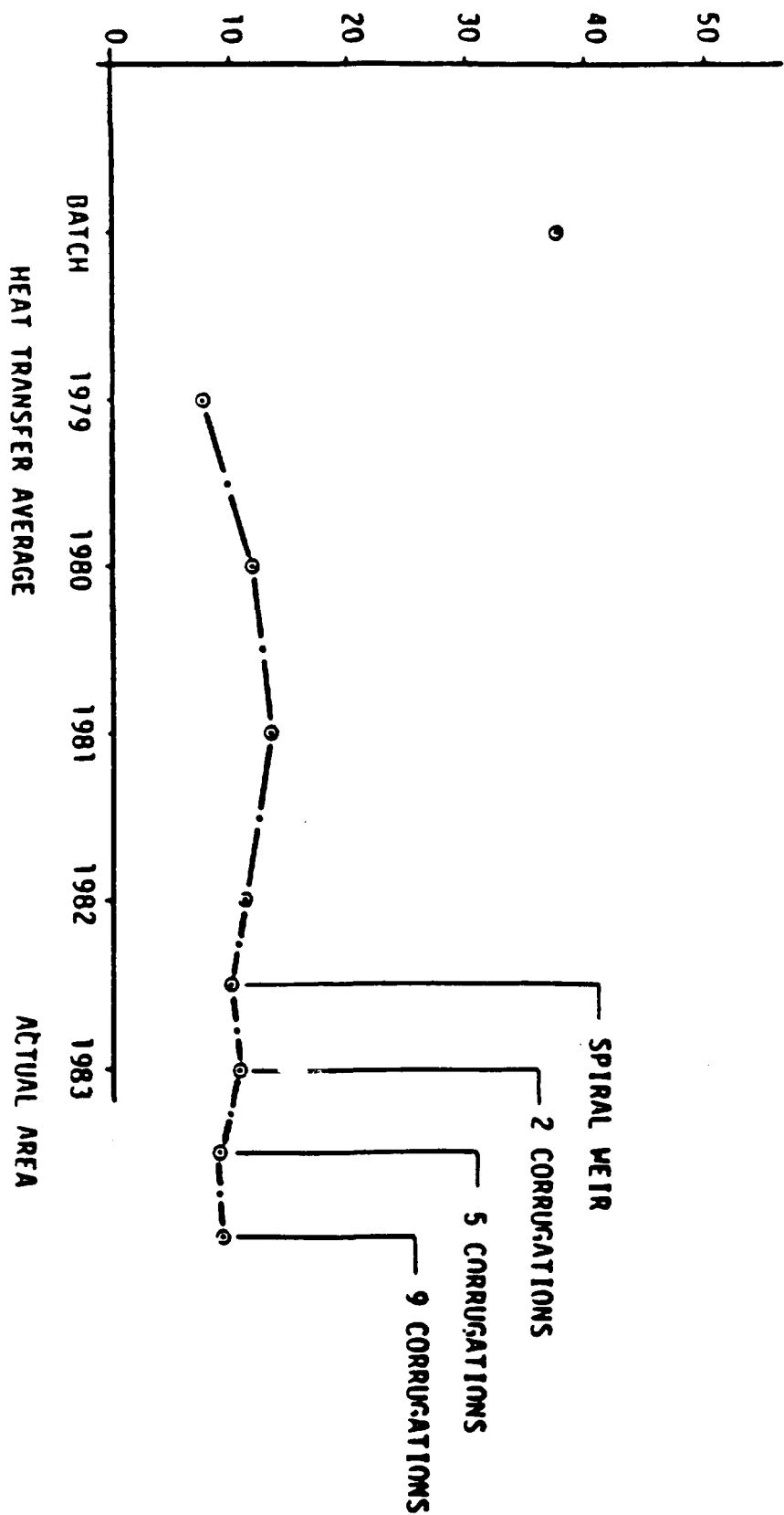
1982

1983

BEST CASE



HEAT TRANSFER COEFFICIENT TAILINGS TO FEED



Feed Grade	YIELDS - WT%			CLOSURE	BLENDED OIL PRODUCT	
	Oil Products C4+	Off-Gas C3-	Coke	Sum of Products Over Feed Wt%	°API	RCR
BOTTOMS RECYCLED TO EXTINCTION						
6%	70.9	7.3	21.3	102.0	24.6	.75
10%	74.7	8.0	17.3	97.7	23.7	.67
12%	73.3	8.2	18.5	98.7	24.0	.71
14%	78.1	6-7	14-16	93.97	23.7	.60
SINGLE PASS YIELDS (NO BTM. RECYCLE)						
6%	72.3	7.5	20.2	106.3	23.7	1.80
10%	78.1	7.9	14.0	97.2	22.7	3.2
14%	78.0	8.2	13.8	98.0	22.5	2.4

The following table provides 1984 design yields for the Processor for extremes of oil sands feed grade.

**YIELD PATTERN VERSUS FEED GRADE
TACIUK PROCESSOR WITH BOTTOMS RECYCLE**

Product	YIELDS, WT% OF BITUMEN		
	7.0% Oil Sands (low)	11.6% Oil Sands (average)	14.0% Oil Sands (high)
C ₃ &+ gas	8.7	8.7	8.7
C ₃ &+ liquid	71.5	73.9	75.2
Gross Coke	<u>19.8</u>	<u>17.4</u>	<u>16.1</u>
TOTAL	100.0	100.0	100.0

The following Table summarizes the oil product comparative analyses obtained from two extended runs processing average grade and low grade ores.

OIL PRODUCT COMPARATIVE ANALYSES

<u>Fraction</u>		<u>12% Feed Oil Sand</u> <u>Product Oil</u>	<u>6-7% Feed Oil Sand</u> <u>Product Oil</u>
Crude	°API	22.7	22.1
	S %wt	3.30	3.25
	CCR	1.15	1.63
	Pour point	below - 30°C	
	Viscosity 40°C	12.23	11.06
	Sediments %wt	.026	.04
Naphtha (IBP to 204°C)	Vol %	24.5	24.4
	°API	54.2	52.1
	S %wt	1.28	1.37
	N ppm	200	370
Distillate (204°C to 343°C)	Vol %	29.3	33.4
	°API	23.4	22.4
	S %wt	2.56	2.55
	N ppm	550	670
	Viscosity 100°C	8.8	8.6
Gas Oil (343°C to 524°C)	Vol%	42.6	38.0
	°API	10.8	10.1
	S %wt	4.2	4.45
	N ppm	2220	2250
<u>Fraction</u>		<u>12% Feed Oil Sand</u> <u>Product Oil</u>	<u>6-7% Feed Oil Sand</u> <u>Product Oil</u>
Residua (+524°C)			
Viscosity	Vol %	3.6	4.1
	°API	-0.3	-3.1
	S %wt	5.23	5.19
	N ppm	5490	2500
	100°C	2670	15800
		CCR	22.9
			24.9

In a commercial operation the +524°C Residua would be separated in the fractionator and recycled to extinction. This will enable us to produce a somewhat lighter product oil than indicated by the above analysis.

The anticipated hydrogen consumption for this feed stock would be very similar to that required by products obtained from commercial fluid coking operation.

2.8.2 Hot Water Extraction - Fluid Coker Overall Yield Pattern

In order to compare the overall Taciuk Processor recovery with that of the present hot water/fluid coker flowsheet, it is necessary to assume certain yield values. The ERCB presented a paper in Caracas, Venezuela in 1982, which contained a curve of hot water efficiency versus feed grade. This is presented as Figure 2.8.2A and is used to project yields. The fluid coker product yields, as published, are as follows:

C ₃ -Gas	- 7.8%
C ₄ ⁺	- 75.4%
Gross Coke	- <u>16.8%</u>
Feed Oil	- 100.0%

If the hot water extraction recovery value from Figure 2.8.2A is coupled with the fluid coker yield, and a secondary loss due to naphtha centrifuging is added, we arrive at a combined recovery for the HW-FC plant. This would be as follows. (Values in %wt based on bitumen content in the feed being 100%.)

Oil Sand Feed Grade	Hot Water Recovery of Bitumen	Secondary Losses	Feed to Fluid Coker	Fluid Coke C ₄ ⁺ Oil Product	Taciuk Processor C ₄ ⁺ Oil Product
7%	34	3	31	24	71
10%	76	2	74	56	73
12%	88.5	1.5	87	65	75
14%	92	1	91	68.6	76-78

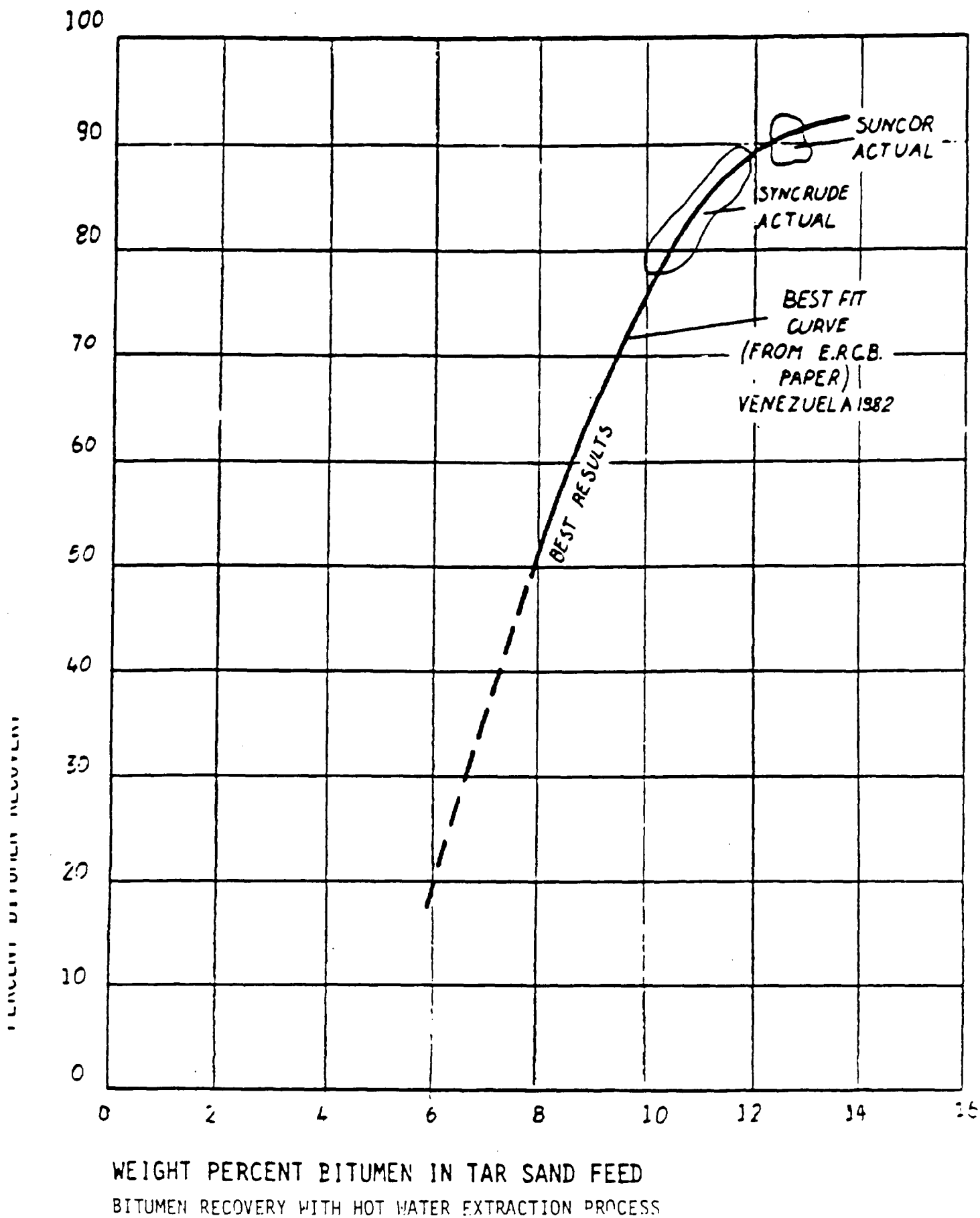


FIGURE 2.8.2A
2-22a

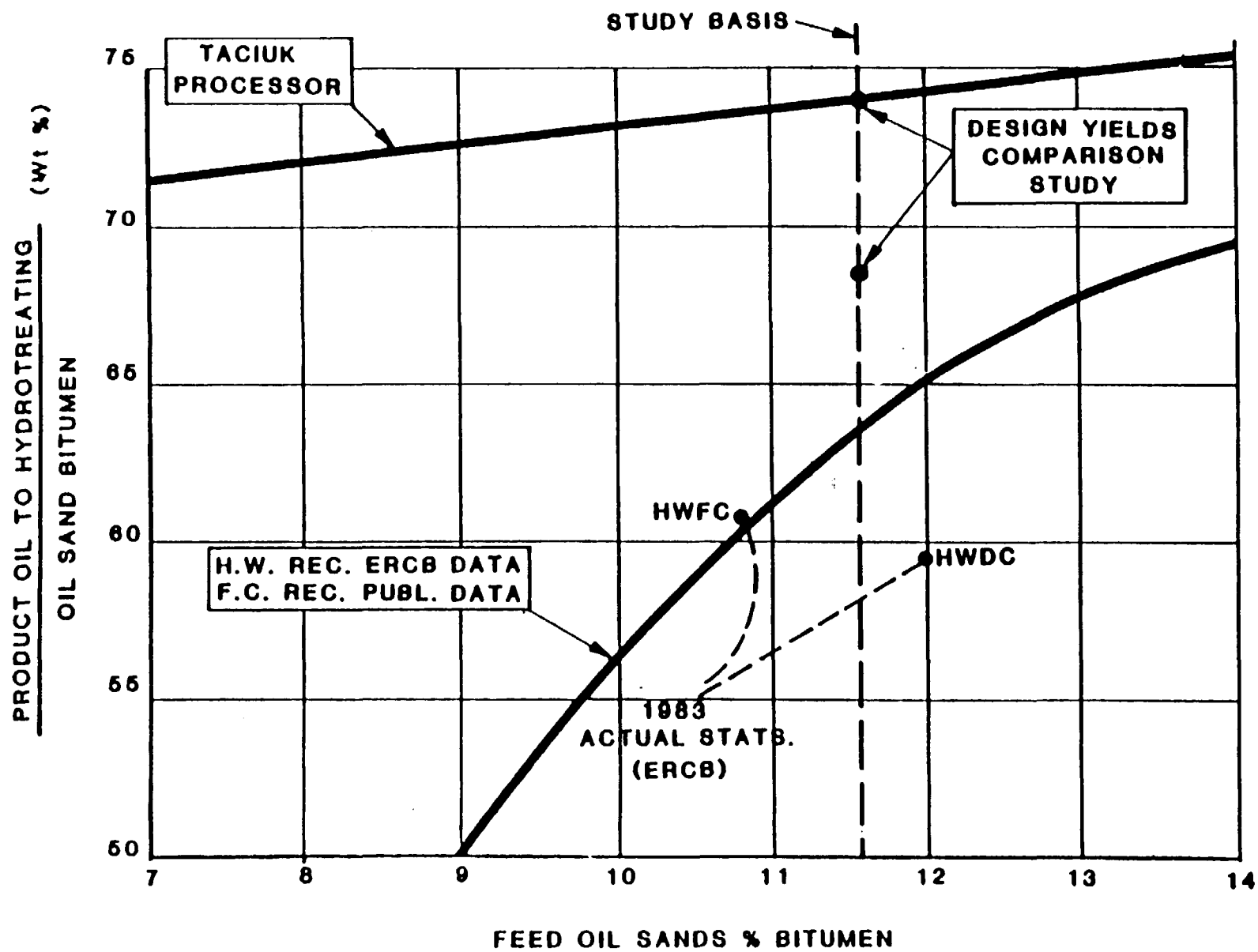


FIGURE 2.8.28

Figure 2.8.2B illustrates the recovery pattern for both processes with changing feed grade. These HWFC values are close to the original design values. Section 3.5.1 deals with commercial HWFC plant actual performance.

REPORT
AOSTRA SEMINAR
PRESENTATION
1985

**TACIUK PROCESSOR
FINAL DEVELOPMENT LEADING TO
COMMERCIAL USE IN OIL SANDS**

For Presentation At:

**AOSTRA SEMINAR
"ADVANCES IN PETROLEUM RECOVERY
AND UPGRADING TECHNOLOGY, 1985."**

**Location:
Edmonton Convention Centre
June 6 - 7, 1985**

**Author: W. Taciuk,
Executive Vice President.**

**UMATAC Industrial Processes
A Division of Underwood McLellan**

INTRODUCTION

UMATAC Industrial Processes Division of UML, in co-operation with the Alberta Oil Sands Technology and Research Authority (AOSTRA), has developed a direct thermal process which simultaneously cracks hydrocarbons present in oil sand feed, recovers the liquid oil fractions as a hot vapor, recovers the gas fractions and burns coke deposited on the host sand to provide the major heat requirements of the process. Initial development started in 1975 with batch scale testing. In 1977 development agreements were signed with the Alberta Oil Sands Technology and Research Authority (AOSTRA) whereby a pilot plant would be constructed and operated in Calgary (Phase A). This plant was completed in early 1978, initially operated as coker during 1978 using a reduced crude feedstock for initial testing simplicity, then operated during 1979 and 1980 on various grades of oil sand feeds. Process and operating data provided encouraging results for plant performance and proved the basic concepts.

During the period 1981 - 1982 (Phase B), further test work on oil sands varying in bitumen content from 6% to 14% was successfully completed.

During the period 1983 - 1984 (Phase I), efforts were concentrated on scale-up definition, demonstration and commercial processor design and on capital and operating cost comparisons relative to processes now in commercial use.

In 1984, a proposal, including definition design and cost estimates, for a 90 tonne/hour Demonstration Project was completed and submitted to AOSTRA. This proposal was accepted by the board and AOSTRA has since been engaged in negotiations with potential participants.

This paper provides a status summary for the Taciuk Processor and discusses the planned program for commercial implementation.

PROCESS GENERAL DESCRIPTION

The Taciuk Processor consists of a single, horizontal, rotating vessel which includes individual compartments to perform the processing steps required to recover a pumpable oil product. (Reference Flow Schematic No. 1.)

As-mined oil sand feed is introduced into the preheating section of the Processor where connate water is evaporated as steam, frozen material is ablated, oversize material is removed and oil sands are heated by heat exchange with the hot outgoing tailings sand. The preheated oil sands are then transported into the reaction zone where they are mixed with hot combusted sand from the combustion zone. The resulting temperature is adequate to thermally crack the hydrocarbons yielding a vapor stream containing the cracking reaction gases and liquids (in vapor form) and a coke residue coating on the sand. The hydrocarbon vapor stream leaving the processor is passed through cyclones to remove fine solids, then processed through a fractionating tower where liquid fractions may be separated for further processing. Fractionator off-gases are further cooled to condense light ends and water, then passed to a central gas processing plant to recover additional light ends. A heavy bottoms oil cut from the fractionating tower can be recycled back to the processor reaction chamber or used as supplemental process fuel. The product oils are pumped to downstream, or remotely located, hydrotreating facilities.

The coke-coated sand, leaving the reaction zone, discharges into the combustion zone. In this zone, preheated air is injected to burn most of the coke to provide heat for the Processor. Auxiliary burners are available to provide heat for startup, trim control and emergency conditions. The hot sand from the combustion zone passes through a recycling arrangement that ensures an adequate supply of hot sand to the reaction zone, while allowing net sand to move into the outer heat

exchange compartment. As the net sand flows through this zone, it is cooled by giving up heat to the incoming oil sand feed. The partially cooled tailings sand is removed from the processor, further cooled and wetted by water addition, then transported by conveyors to a tailings area. Combustion gases leaving the processor flow through cyclones to reduce the fine solids, then pass through a wet scrubber that removes most of the remaining fine solids and chemically removes most of the sulfur dioxide produced by the combustion of coke. The wet scrubber liquid is used as a cooling medium for the tailings sand.

OVERALL DEVELOPMENT STRATEGY

The initial planning for Taciuk Processor development assumed that the thermal cracking characteristics and yields of the reaction zone be similar to those obtained by the fluid coking process. The major development areas were in the heat exchange zone, the coke combustion zone, the use of simple seals and in the mechanical integrity of the machine. Development for, and verification of, size scaleup criteria was a major concern and the following Processor capacities were selected for this purpose.

- a) Pilot Processor 5 tons/hour feed rate.
- b) Demonstration Processor 100 tons/hour feed rate.
- c) Commercial Processor 1,000 tons/hour feed rate.

This placed the initial scaleup ratio, to demonstration, at 20 to 1 and the final scaleup ratio to commercial at 10 to 1. In addition to pilot plant operations, considerable emphasis was placed on bench scale research so that the combined results would provide data for establishing mathematical models for the process and equipment designs. These models were verified by additional pilot plant test programmes and are used to establish candidate designs for demonstration and commercial Processors.

The development strategy adopted by UMATAC, in co-operation with AOSTRA, involved the setting up of a series of "phase" programmes. Each phase was tied to a set of objectives. The performance of each phase was measured by the degree of success in achieving the stated objectives. The following tabulation summarizes the major phases, states the accomplishments of completed phases and states the objectives of future planned phases.

PROJECT CONCEPTION - 1974-1975

INITIAL PHASE - 1975 START

- * Bench scale test work.
- * Preliminary design of processors.
- * Initial research into process parameters.
- * Obtain funding agreements.

PHASE A - 1977 START

- * Pilot plant design and construction.
- * Pilot plant initial operations.
- * Operations on oil sands.
- * Determination of process variables.
- * Plant modifications.
- * Research into process parameters.
- * Steady-state plant operations.
- * Preliminary mechanical designs of commercial sized processors.

PHASE B - 1980 START

- * Objectives similar to Phase A but concentrate on longer steady-state runs for 6% to 14% oil sand feeds.
- * Oil product detail analysis.
- * Specific research programmes to establish design and scaleup basis.
- * Produce more detailed processor and plant layout designs.
- * Obtain industry consultive participants.
- * Detailed technical review.
- * Establish preliminary comparative plant

economics for Taciuk Processor versus Hot Water - Fluid Coking.

- * Define the Demonstration Plant Phase of the development programme.
- * Obtain funding agreement for next phase of development.
- * Consultive participation by Gulf and Canstar.

PHASE 1 - 1982 START

- * Complete sufficient detailed engineering to develop a definitive capital and operating cost estimate for the demonstration project.
- * Prepare general design and cost estimates for commercial plants.
- * Provide input data for an independent contractor to complete capital cost and operating cost comparisons for Taciuk Processor Plants versus Hot Water - Flexicoking Plants.
- * Continue pilot plant operations to provide additional data for detailed design purposes.
- * Assist in plant site selection, site layouts, schedules, etc.
- * Study requirements for licenses and permits for demonstration plant.
- * Assist AOSTRA in discussions with potential third party project participants.
- * Finalize agreements for construction and operation of the demonstration plant.

PHASE II - READY TO START

- * Final design and construction of the Demonstration Project.
- * Operations personnel training and project staffing.
- * Operate the plant for a scheduled two year period to:
 - ** Verify scaleup data.
 - ** Verify process performance related to oil quantity, oil quality, heat exchange, coke combustion, flue gas desulfurization, compliance with effluent codes, etc.
 - ** Obtain data on processor design mechanical integrity, wear rates, corrosion rates, rating factors, etc.
 - ** Obtain data on fouling rates, any tendency

for buildups and pluggages as well as other operational problems.

- ★★ Obtain data on maintenance requirements to maintain operating availability.
- ★★ Determine process and machinery stability during extended runs with a range of oil sand feeds from 6% to 14% bitumen content.
- * Maintain UMATAC head office staff to continue with commercial unit studies and designs, assess impact of demonstration plant results on commercial designs and continue with research and development in areas that could further improve process or mechanical designs.
- * Increase research efforts into other potential use areas such as - use of processor as a coker for heavy oils or insitu oils, processing of oil shales, cleanup of spills, etc.
- * Provide data, designs, etc. to potential commercial plant operators.

PHASE III - FUTURE (1989?)

- * Finalize agreements for initial commercial (prototype) processors.
- * Proceed with design and construction of first commercial units.
- * Verify prototype commercial units' performance versus design.
- * Carry out modifications as considered necessary to meet guarantees or re-assess rating (up or down) as determined from the long-term testing of these commercial units.
- * Continue efforts to develop alternative uses for processor or related technology.
- * Provide long-range engineering and operating service to Taciuk Processor plant operators. These would include operating assistance, maintenance and/or operating cost improvements, etc.
- * Continue research and development efforts in area of process or plant improvement as related to changing economics.

The initial Phases A, B and I have been completed by UMATAC and, at the present time, UMATAC is continuing with the Demonstration Project

planning along with secondary research in the area of potential alternative uses. AOSTRA has agreed to fund at least 50% of the demonstrator project and are actively engaged in discussions with possible industry partners on the basis of 12½% equity participation.

PROCESSOR DEVELOPMENT COSTS AND SCHEDULES

The following table illustrates the actual and estimated costs for development phases as described earlier.

Phase A	2.9 million dollars
Phase B	2.7 million dollars
Phase I	4.5 million dollars
Phase Ia	2.6 million dollars (including hydrotreating test allowance)

Total expenditures to date 12.7 million dollars.

These funds have been provided by AOSTRA under the terms and conditions set forth in AOSTRA/UMATAC development agreements.

PHASE II - DEMONSTRATION PROJECT ESTIMATED COSTS

Construction	35 million dollars
Operation for 2 years	36 million dollars
Allowances	<u>4</u> million dollars
Total	75 million dollars.

Phase III - Not estimated - is dependent on when contracts are negotiated with commercial users and the terms and conditions of such contracts.

On the basis of a mid 1985 authorization to proceed with the

Demonstration Project, the future development schedule would be projected as follows.

Demonstration Project start -	mid 1985
Construction completed -	mid 1987
Operations start -	July 1987
Operations completed -	July 1989.

UMATAC head office staff would be engaged in continually monitoring the demonstration plant's performance so that process and mechanical designs for the prototype commercial processors would be updated. Once the plant is able to operate at the design conditions, more detailed engineering can be completed on the commercial processors and commercial plants. At this stage (approximately mid 1988), it would be possible to begin contractual negotiations with commercial ventures. The first commercial units could then be designed, fabricated and installed, ready for operation by years 1993 or 1994.

PRESENT TECHNICAL STATUS

The following data presents a summary of the technical status of the project development as of early 1985.

1) Partec Lavelin Comparative Economic Evaluation.

In 1983, Partec Lavelin was commissioned by AOSTRA to complete a capital and operating cost comparison for two sizes of commercial plants utilizing either the Taciuk Process or the Hot Water - Flexicoking Process. The evaluations used identical oil sand feed rates for the two flowsheets.

The following tables summarize results from this study. Note that costs exclude all royalties and income taxes.

Large Plant Case (78MM tons/year of feed)

	<u>HW/FC</u>	<u>TACIUUK</u>
Oil sands feed rate (TPCH)	8904	8904
Synthetic crude production (BPCD)	106418	119417
Natural gas import (MMSCFD)	13.3	65.73
Constructed cost (\$MM)	3706	3641
Constructed cost (\$/BPCD)	34,794	30,489
Operating Cost (\$/BBL)	10.90	10.72
PCF ROR (%)	31.4	36.6

Small Plant Case (22MM tons/year of feed)

	<u>HWFC</u>	<u>TACIUUK</u>
Oil sands feed rate (TPCH)	2512	2512
Synthetic crude production (BPCD)	30015	33689
Natural gas import (MMSCFD)	2.44	16.71
Constructed cost (\$MM)	1246	1122
Constructed cost (\$/BPCD)	41475	33326
Operating cost (\$/BBI)	14.00	13.75
DCF ROR (%)	24.2	32.5

2) Process Oil Yields Versus Feed Grade.

The Athabasca oil sand deposits are generally horizontally disposed and waste intrusions form horizontal layers that are difficult to mine selectively. In addition to this, the oil content generally increases from the top toward the bottom of the deposit, thus making it difficult to maintain a consistent oil sand feed grade and fines content. A process that is insensitive to fines content and oil feed grade relaxes mining constraints and results in lower

operating cost, and higher more consistent synthetic oil production. The Taciuk Processor has been repeatedly tested on low grade, high fines oil sand and exhibits only a minor sensitivity to these variables when compared to the existing hot water extraction - dilution centrifuging flowsheet. The following table provides the yield pattern for the Processor with varying oil sands feed grades.

Yield Pattern Vs. Feed Grade
(in weight % of bitumen feed)

<u>Product</u>	<u>7%</u>	<u>11.6%</u>	<u>14.0%</u>
C ₃ &- Gas	8.7	8.7	8.7
Gross Coke	19.8	17.4	16.1
C ₄ &+ Oil to Hydrotreating	71.5	73.9	75.2
Oil to Hydrotreating from Hot Water - Flexicoking	25 to 40	63.5	69.0
Processor Recovery Improvement	+100%	+16.4%	+ 9.0%

Since the Processor uses heat to thermally crack the bitumen on the oil sands, it is not sensitive to fines content, moisture content, oil content and bitumen specific gravity. The tailings sand produced is completely clear of hydrocarbons.

3) Process Advantages.

Advantages of use of the Taciuk Processor versus the existing Hot Water - Flexicoking technology are judged to be as follows:

- * Produces a dry, oil-free tailings sand.
- * Eliminates need for cokers.
- * Processes low grade ores.
- * Consistent high liquid yield.
- * Produces a light, pumpable product oil directly (hydrotreating can be carried out at remote locations).

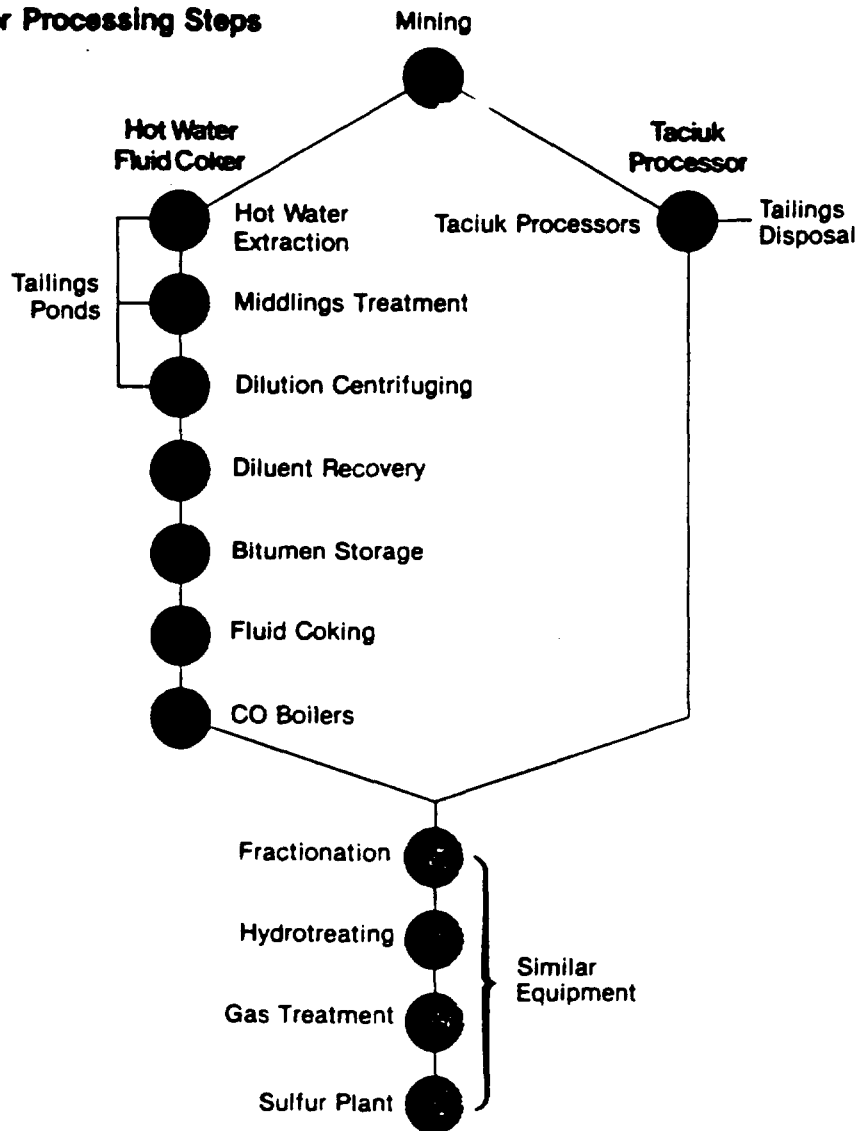
- * Less complicated mining area plan.
- * Lower water requirements.
- * Lower capital costs.
- * Environmental and land reclamation advantages.
- * Multiple trains provide for staged project development. Multiple trains provide for maintenance and operating scheduling flexibilities and economics.

4) Process and Equipment Simplification.

Manpower costs form a very significant portion of an oil sand plant's operating costs and the number of personnel required is partially determined by the plant site size and complexity. Since the Processor produces a thermally cracked oil directly, this eliminates many of the Hot Water System process steps, including a large amount of "de-coupling" storage tankage for bitumen and naphtha between the extraction steps and the coking step.

The following diagram illustrates the major process steps that are eliminated by use of the Taciuk Processor.

Mined Oil Sand Plants Major Processing Steps



The Taciuk Processor plant handles bitumen only as it exists in the oil sand feed storage and conveying systems. This minimizes exposure to bitumen spills, leaks, heat traced piping, heated storage, etc. that is required for HWFC plants.

CONSULTIVE PARTICIPANTS

In late 1981, Canstar Oil Sands Ltd. and Gulf Canada Resources joined the development program as consultive participants. Both of these companies participated in detailed discussions with UMATAC/AOSTRA committees and provided many helpful comments regarding technical and operational evaluations during the Phase B period. Canstar Oil Sands Ltd. continued as a participant during Phase I of the program. UMATAC appreciates the assistance, critiques and suggestions provided by the participants.

CONCLUSION

This paper has presented a brief summary of the Taciuk Processor overall development program leading to commercial acceptance of the process. The development period spans a period of 20 years and has a total expenditure in excess of 100 million dollars. Even without delays the first commercial units cannot be ready for operation prior to 1993 and the National Energy Board along with the Alberta Energy Resources Conservation Board, both forecast an accelerated requirement for additional oil sand plants starting in the late 1980's. The oil sands is a proven resource whose development requires the right combination of fiscal policies along with an oil industry psychology of "mining and manufacturing". These, coupled with prudent use of developing technologies, can ensure a positive and productive development plan for use of oil sands as a major natural resource well into the next century.

ACKNOWLEDGEMENTS

The author expresses his thanks to the members of AOSTRA, members of the UMA Group and employees of UMATAC for the team efforts involved in progress made to date on development of this new technology. Without

the continuing financial support and understanding of the Alberta Oil Sands Technology and Research Authority, which will span a period well in excess of 10 years, this project would not have been possible.

The Taciuk Processor - Internal Process Flows

Within a horizontal, rotating kiln, processing steps take place in individual compartments or "zones."

1 Mined oil sand is fed into a *preheat zone* in which the connate water is evaporated. Frozen material is ablated and the feed charge preheated by the tailings sand.

Oil Sand Feed Conveyor

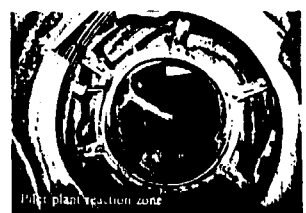
Over-size Rejects
Over-size material which could hamper operation is removed from the preheat zone through reject chutes.

7 Tailings Sand
The cooled, coke-depleted tailings sand exits the kiln for disposal in the mined out area.

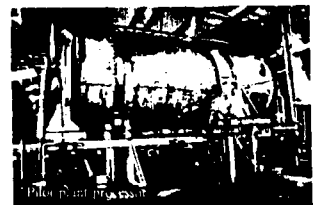
8 Flue Gases
The combustion gas flows to a flue gas treating system.

Steam

6 The balance of the tailings sand flows into a *cooling zone*. Here, the heat contained in the tailings sand and the combustion gas is transferred to the incoming fresh oil sand feed.



2 The preheated, dry oil sand flows into the *reaction zone* where it is intimately mixed with hot, oil-free tailings sand. The temperature of the mixture is sufficient to thermally crack the bitumen in the oil sand and vaporize the hydrocarbon products.

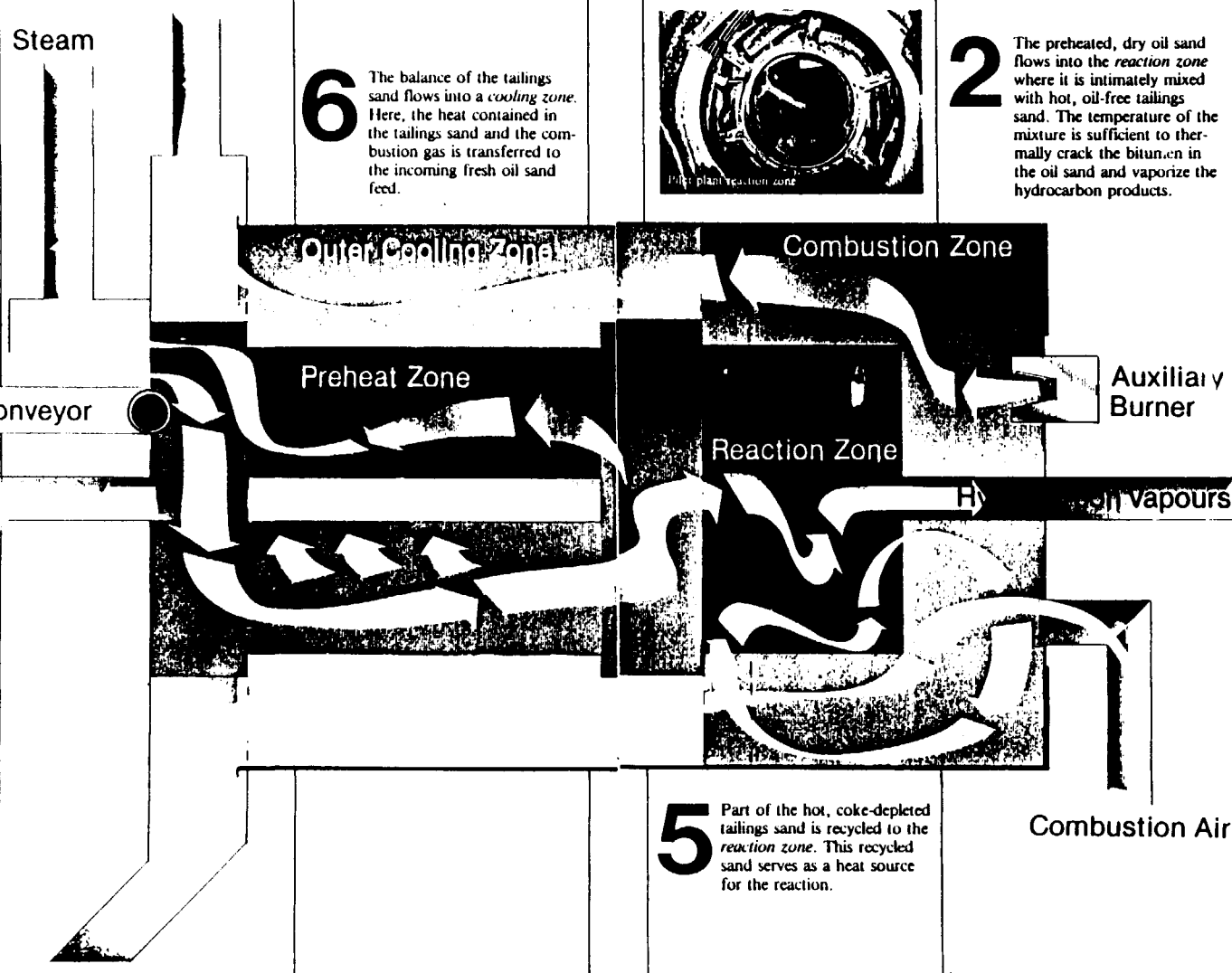


3 The vaporized, cracked hydrocarbons flow out of the processor for recovery in a typical refinery system.

4 Coke formed by the cracking operation coats the inert sand. Coked sand flows into a *combustion zone* where preheated air is introduced to burn the coke to provide heat for the process. Auxiliary fuel is added to the combustion zone for trim control and start-up.

5 Part of the hot, coke-depleted tailings sand is recycled to the *reaction zone*. This recycled sand serves as a heat source for the reaction.

Combustion Air



LABORATORY
AND
SAMPLE TESTING

UMATAC INDUSTRIAL PROCESSES

BATCH THERMAL CRACKING TEST APPARATUS

In late 1984, UMATAC constructed a revised batch thermal cracking test apparatus to conduct general reaction zone tests. The apparatus simulates the conditions present in the Taciuk Processor and can also be used for small scale testing of candidate feed stocks. Since this is a batch process, the vapor residence time and the off-gas sample analysis must be adjusted to reflect differences between batch and continuous flow reactors. These effects can be minimized by running two or three tests in succession without removing the sand charge or diluting the vapors remaining in the test drum between tests.

EQUIPMENT DESCRIPTION

The test equipment consists of the following apparatus (see attached sketch):

1) Test Reactor

The sand reactor is a drum which is twelve (12) inches in diameter and twelve (12) inches long. The drum is rotated at speeds of 3 to 16 rpm by an adjustable speed electric drive system and is electrically heated by 6 KW of heaters installed on the outside of the steel shell. A three (3) inch thick layer of insulation covers all hot drum surfaces. Thermocouples are grouped in three locations and provide three (3) steel shell temperatures, three (3) sand temperatures and a central hot vapor temperature. A series of slip rings are used to provide electric power to the heaters and to obtain the thermocouple outputs. A four (4) inch diameter threaded pipe nipple and cap are used for feed and discharge access into the drum.

2) Hot Vapor Condensing System

Hot vapors produced in the reactor flow through a double pipe header, through a rotary seal, then to an inclined condenser tube. The condenser tube is externally cooled by cold water circulation. Hot water can also be used for cooling to minimize trapping of oil in the condenser tube. Condensed liquids drain by gravity to a liquid collector standpipe which is equipped with a nitrogen bubble tube so that a liquid level can be detected and recorded during each run.

3) Gas Metering and Sampling System

Vapors, which have not been condensed in the condenser, pass up a 1/2" diameter copper tube and on to a gas filter trap. Any liquids which may condense along this tube can drain back to the liquid standpipe or are trapped in the gas filter. Gases passing the filter are discharged to a plastic gas collector bag through wet gas meter No. 1. This meter measures the quantity of gas evolved during the test and is equipped with a pulser switch which provides a signal, at .05 cubic foot gas flow intervals, to a recorder. A gas compressor is used to evacuate the gas bag and pressurize a gas sample bomb which is then analyzed by a gas chromatograph.

4) Purge Gas System

A centrally located pipe, passing through the drive assembly, provides a means of injecting purge gas into the reactor prior to, or during a test run. The purge gas, normally nitrogen, passes through wet gas meter No. 2, then through a rotating seal and into the reactor feed pipe.

5) Feed Addition and Coked Sand Discharge

A four (4) inch diameter pipe cap and nipple is used for access to the reactor. This cap is fitted with a one (1) inch valve. At the end of a test run, a small collector tube is fitted to the valve and

is used to collect a coked sand sample for analysis. This minimizes exposure of the hot sand to the outside air. After the sample has been taken, the pipe cap is removed and the coked sand charge is dumped as the unit rotates. Samples of feed for testing are put into the unit via this four (4) inch pipe nipple.

TESTING SEQUENCE

The test apparatus is arranged so that a number of variables, as follows, can be studied:

a) Temperature

The reactor temperature can be adjusted to suit a particular test (up to 1300°F).

b) Charge

The reactor can hold a maximum charge of approximately 30 pounds. This can be made up of an initial sand charge (simulating the processor recycle) and the test feed charge. The run temperature profile and test duration can be altered by changing the ratio of initial charge to feed charge. Normally, a 20 pound initial sand charge is used with a feed sample size of 5 to 10 pounds. Depending on the test purpose, a 30 pound feed sample, with no initial recycle charge, can be used and this would provide a large oil sample at the expense of a long reaction time.

c) Speed

The test reactor speed can be set from 4 to 16 rpm. This provides variable mixing energy and can be used to influence reaction rate (residence time).

d) Purge Gas

A purge gas can be added during test runs. This alters the residence time of vapors in the reaction drum.

A typical test sequence is as follows:

- 1) Heat the drum to test temperature.
- 2) Set drum speed, etc. for test conditions.
- 3) Add initial sand charge and heat to test temperature.
- 4) Purge unit with N_2 for 30 seconds. Ensure that the gas collector bag has been evacuated and the gas meters are at 0. Obtain a sample of the initial sand charge.
- 5) Start recorder and data acquisition systems.
- 6) Add sample, install and tighten seal cap.
- 7) Start unit rotating, record start time.
- 8) The test duration is normally 10 minutes. At low reactor temperatures this time may increase to 20 or 30 minutes.
- 9) At the end of the test the gas meter readings are recorded.
- 10) The gas bag, which normally contains one to three cubic feet of gas, is partially evacuated, then the flow is diverted to the gas bomb to obtain a gas sample for the chromatograph. The remainder of the gas is discharged to atmosphere.
- 11) A sample of coked sand is obtained thru the 1" valve located on the feed cap. The charge is then dumped by removing the cap and starting unit rotation.
- 12) The condensed liquid collector pipe is removed, weighed, then taken to the laboratory for liquid analysis.
- 13) The hot vapor insert tube and swivel are removed and weighed to determine what oil or residues remained there at the end of the run.
- 14) The gas filter trap is removed and weighed.
- 15) The insert tube and trap are cleaned after each run, once they are

weighed.

- 16) The run data, gas bomb, liquid collected and the two sand samples are taken to the lab for analysis.
- 17) Once the analyses are completed, the run data sheets, including product yields and closure errors, are completed for each run.
- 18) The next test proceeds as described above.

NOTE: The errors inherent in batch testing are minimized by running two or three tests in sequence while utilizing the cumulative sand charge. This is done by reducing the initial sand charge to 10 or 15 pounds and using five (5) pound test charges. On completion of the first test, the unit is not taken apart and the sand dumped. Only the gas bag is sampled and evacuated, the liquid collector is changed and the coked sand sample is taken. This preserves the vapor charge in the reactor for the next test. The second test involves momentarily opening the feed hole, adding the feed charge, then repeating the test procedure. This procedure can be repeated until the total charge resident in the reactor reaches 30 pounds.

LABORATORY ANALYSES

UMATAC's laboratory is equipped to do the following tests:

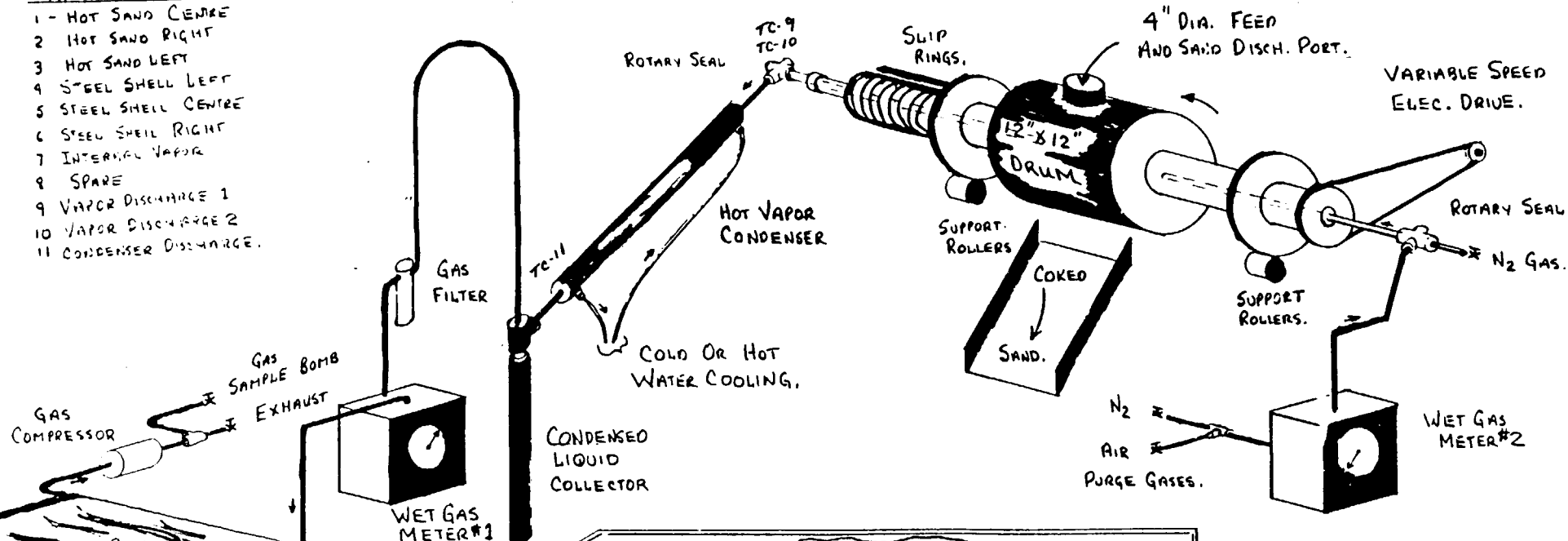
- 1) Gas chromatograph.
- 2) D-1160 distillation.
- 3) Dean Stark oil-water separation and feed analysis.
- 4) Coke by LOI (loss on ignition at 1100°F).
- 5) API (gravity).
- 6) RCR (Ramsbottom Carbon).
- 7) Pentane insolubles.

- 8) BS&W.
- 9) Centrifuge solids determination.
- 10) Solids mesh size structures.
- 11) Fisher assays on feed materials.

These analyses are normally sufficient for UMATAC's testing requirements. Special analyses other than these are contracted to commercial laboratories in the Calgary area.

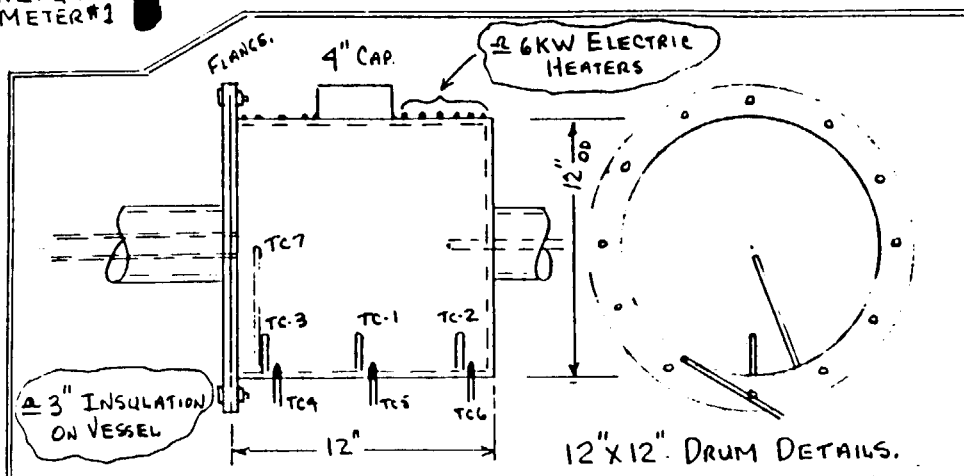
THERMOCOUPLES

- 1 - HOT SAND CENTRE
- 2 HOT SAND RIGHT
- 3 HOT SAND LEFT
- 4 STEEL SHELL LEFT
- 5 STEEL SHELL CENTRE
- 6 STEEL SHELL RIGHT
- 7 INTERNAL VAPOR
- 8 SPARE
- 9 VAPOR DISCHARGE 1
- 10 VAPOR DISCHARGE 2
- 11 CONDENSER DISCHARGE.



DATA RECORDED

- 1- 6 TCS FROM ABOVE
- 2- GAS FLOW RATE
- 3- OIL LEVEL RISE RATE
- 4- TEST DRUM PRESSURE
- 5- CONDENSER DISCH. PRESSURE.
- 6- % O₂ IN OFF GAS (OPTIONAL).
- 7- OTHERS AS REQD.



UMATAC Industrial Processors Ltd. the umat group

TACIUK PROCESSOR
BATCH THERMAL CRACKING
TEST APPARATUS ARR'G'T.

DATE - NOV. 1984

BY - W. TACIUK

VPR. VOLUME - $12" \times 12" = 0.785 \text{ cu. ft.}$
 SAND VOLUME = .08 cu. ft.
 NET VOLUME = .70

FOR $4" \times 12"$ UNIT = .261 cu. ft.
 SAND VOLUME = .08
 NET VOLUME = .18

REDUCTION = $\frac{.52}{.70} = 74\%$

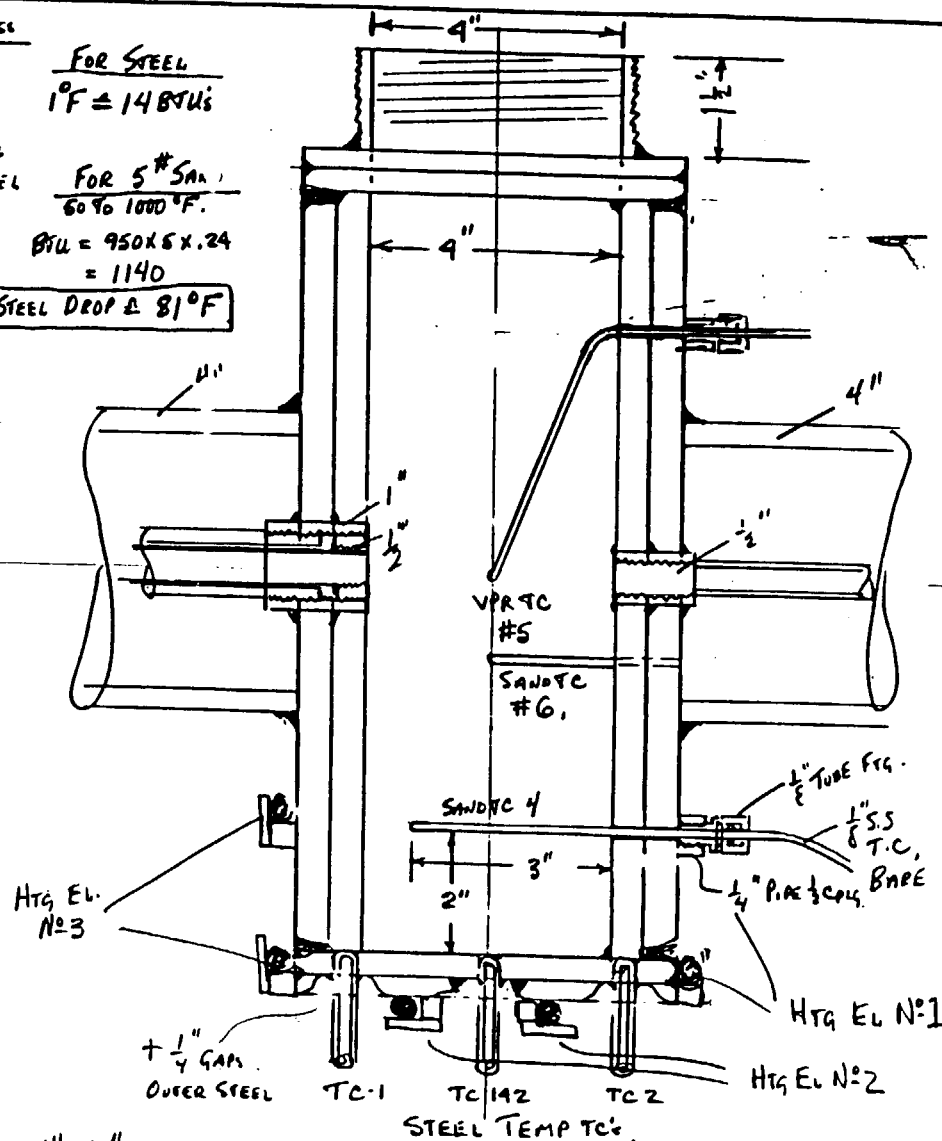
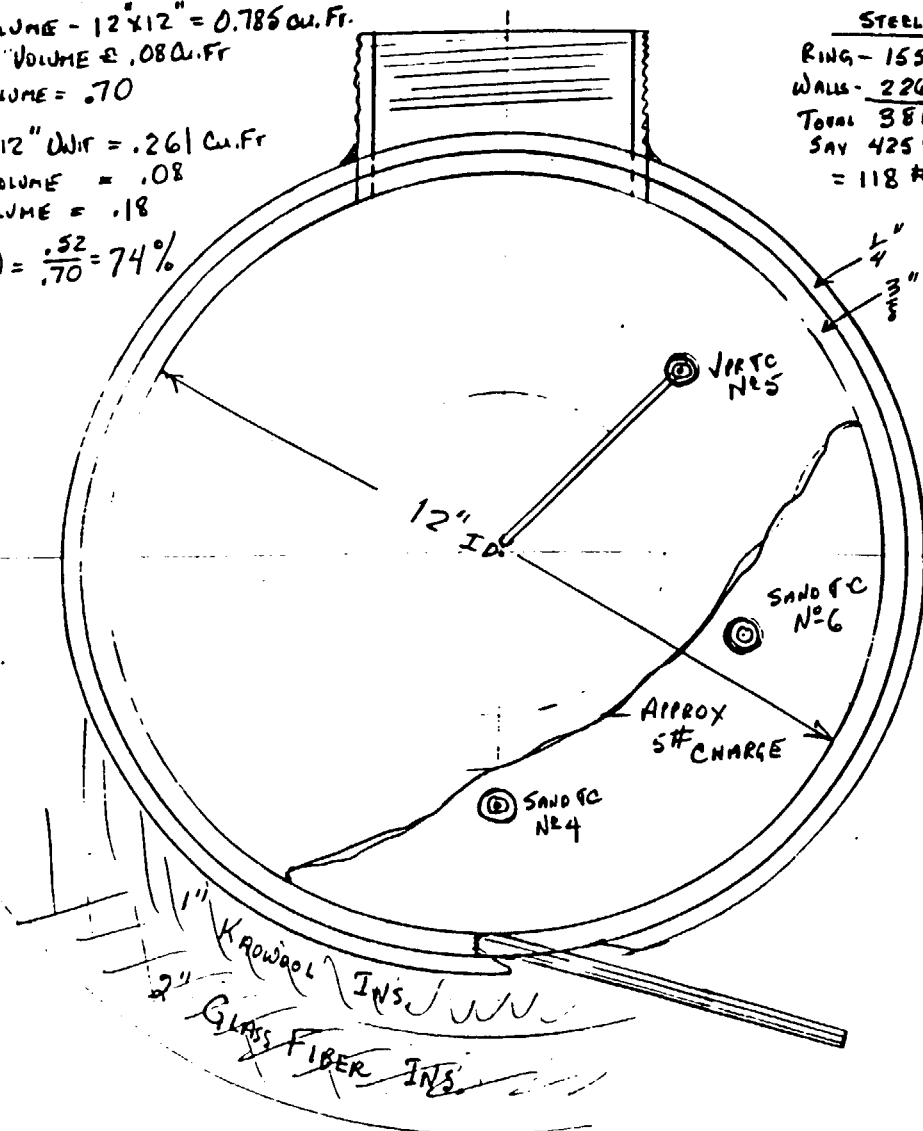
STEEL MASS
 RING - 155 lb
 WALLS - 226 lb
 TOTAL 381 lb
 SAY 425 TOTAL
 = 118 # STEEL

FOR STEEL
 $1^\circ\text{F} \approx 14 \text{ BTU's}$

FOR 5# SAND
 $60 \text{ to } 1000^\circ\text{F.}$

BTU = $950 \times 5 \times .24$
 = 1140

STEEL DROP $\approx 81^\circ\text{F}$



SCALE 1" = 2"

BATCH THERMAL CRACKING
 12" DIA. X 4" WIDE TEST UNIT.

W. JACIUK

MAY 13, 1985



We'd like to
get you out
of hot water...

...and into the Taciuk Process!

Over the past decade, the Alberta Oil Sands Technology and Research Authority (AOSTRA) has been evaluating and developing new and improved technology for the recovery of bitumen from Alberta's mineable oil sands.

From the outset, we recognized that it would be essential for any new extraction process to deliver significant advantages over commercially used Hot Water Extraction methods. AOSTRA has set six objectives that such a process would have to meet to be proven of practical interest to industry. These are:

- Improved bitumen recovery
- Improved processing of lower grade oil sands
- Improved energy efficiency
- Reduced capital and operating costs
- Elimination of tailings ponds
- Reduced water consumption

One method has met most of these objectives. This is the direct thermal

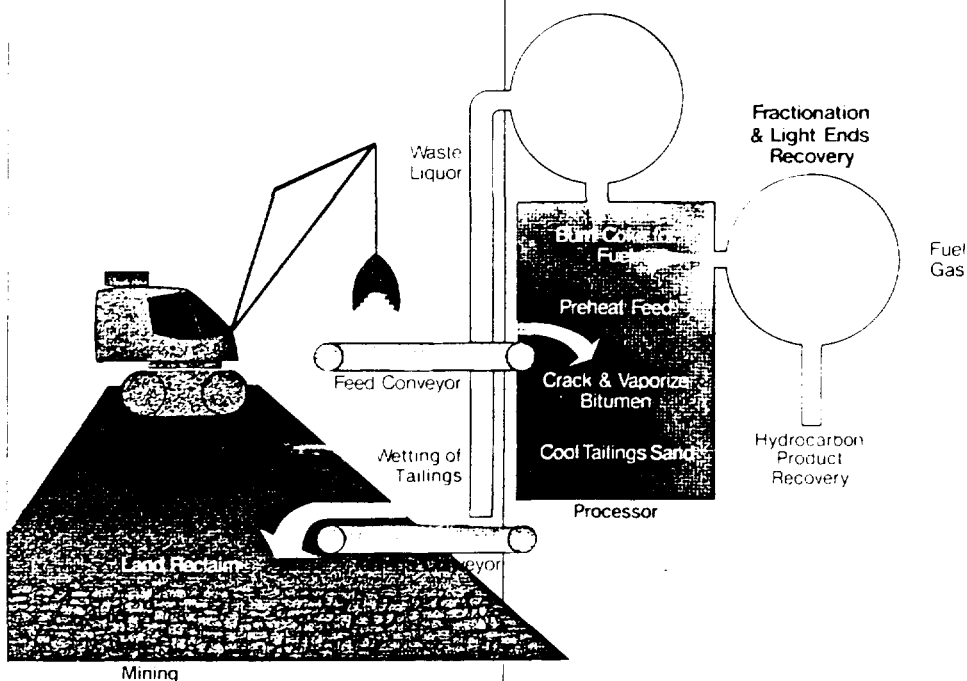


UMATAC Pilot Plant, Calgary, Alberta

retorting process invented by Mr. W. Taciuk of UMATAC Industrial Processes, a division of Underwood McLellan Limited.



Mr. W. Taciuk, Process Inventor



After ten years of research, including seven years of pilot plant testing in a five ton per hour Pilot Plant in Calgary (12,000 tons of oil sand of various grades successfully processed), and a recent impartial evaluation by an independent contractor, AOSTRA has evidence of the technological and economic viability of the Taciuk Process.

It is clear that the time has come to move forward into an expanded capacity Demonstration Plant. We are confident in introducing this concept to you, and inviting you to become a partner in progress in the development of the Taciuk Project.

The Taciuk Processor - Internal Process Flows

Within a horizontal, rotating kiln, processing steps take place in individual compartments or "zones."

1 Mined oil sand is fed into a *preheat zone* in which the connate water is evaporated. Frozen material is ablated and the feed charge preheated by the tailings sand.

Oil Sand Feed Conveyor

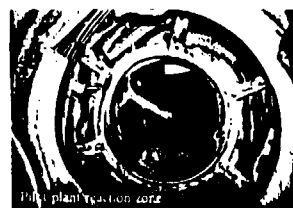
Oversize Rejects
Oversize material which could hamper operation is removed from the preheat zone through reject chutes.

7 Tailings Sand
The cooled, coke depleted tailings sand exits the kiln for disposal in the mined-out area.

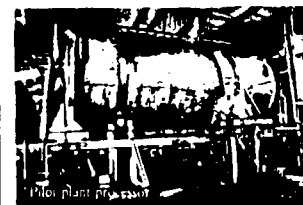
8 Flue Gases
The combustion gas flows to a flue gas treating system.

Steam

6 The balance of the tailings sand flows into a *cooling zone*. Here, the heat contained in the tailings sand and the combustion gas is transferred to the incoming fresh oil sand feed.



2 The preheated, dry oil sand flows into the *reaction zone* where it is intimately mixed with hot, oil-free tailings sand. The temperature of the mixture is sufficient to thermally crack the bitumen in the oil sand and vaporize the hydrocarbon products.

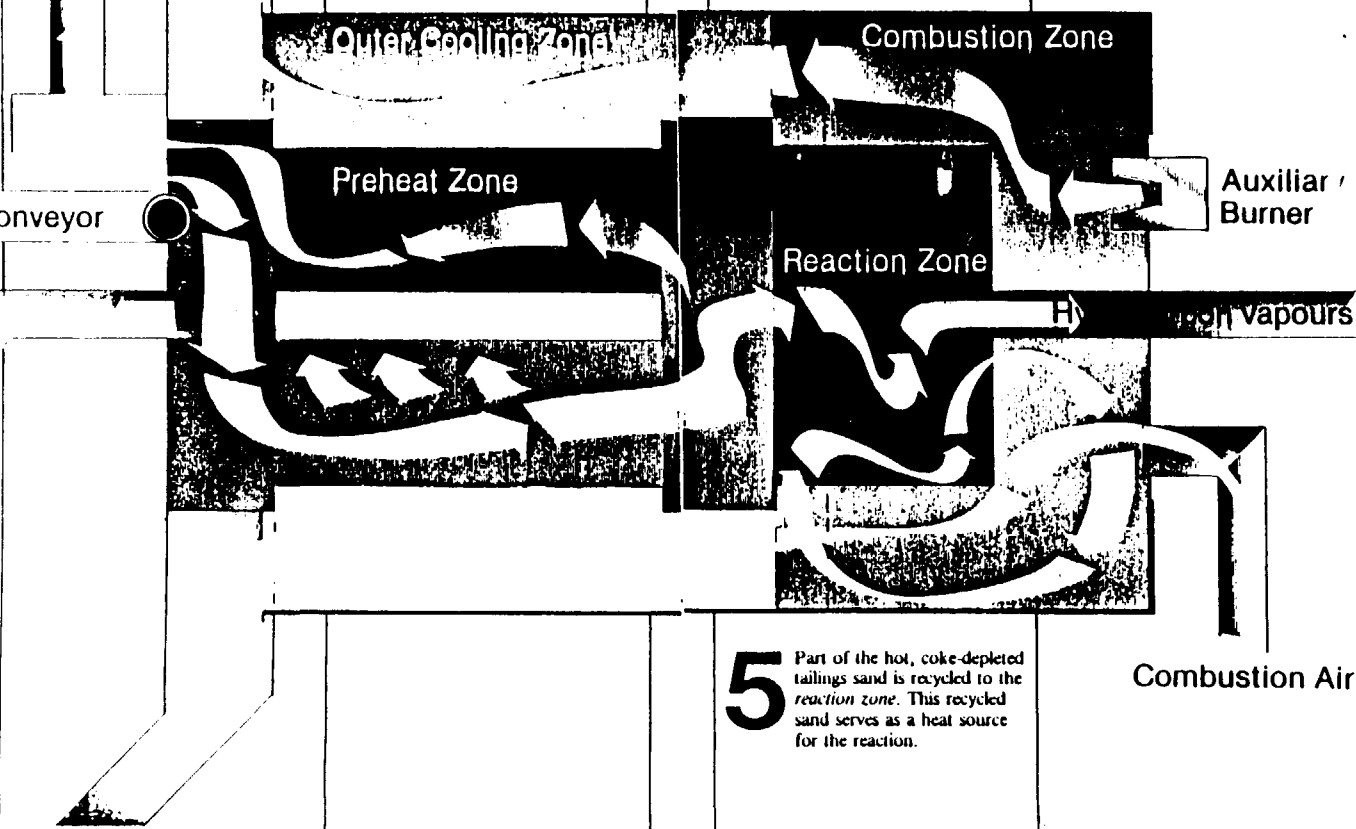


3 The vaporized, cracked hydrocarbons flow out of the processor for recovery in a typical refinery system.

4 Coke formed by the cracking operation coats the inert sand. Coked sand flows into a *combustion zone* where preheated air is introduced to burn the coke to provide heat for the process. Auxiliary fuel is added to the combustion zone for trim control and start-up.

5 Part of the hot, coke-depleted tailings sand is recycled to the *reaction zone*. This recycled sand serves as a heat source for the reaction.

Combustion Air



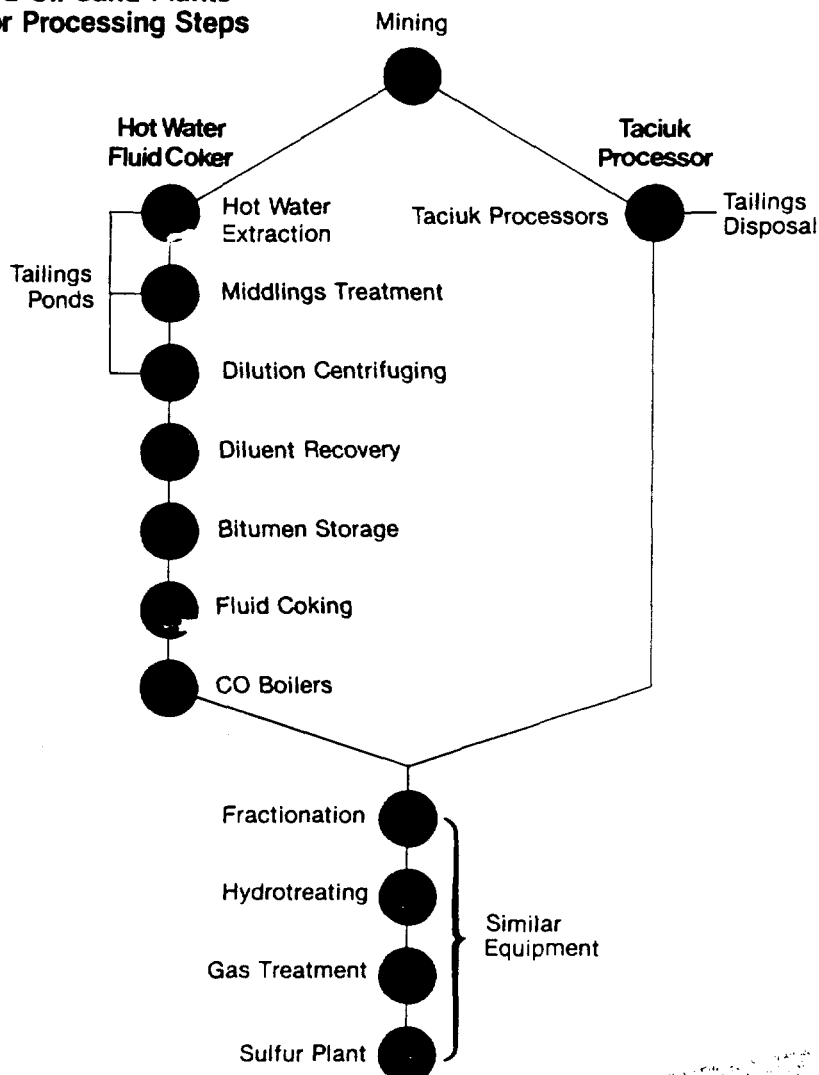
Process Advantages

Unlike current commercial operations, the Taciuk Process combines extraction and primary upgrading processes into one process operation. The Taciuk Process offers six, distinct technical advantages:

- Consistent, high liquid hydrocarbon recovery from oil sands containing 4 to 14 per cent bitumen
- Elimination of upgrader residue
- Production of dry tailings - elimination of tailings ponds
- Elimination of the need for separate extraction and primary upgrading processes
- Reduction of process water requirements
- Improvement in energy efficiency.

Technological advantages must ultimately be reflected in economic advantages. Partec Lavalin Inc., an independent consultant, has conducted a comprehensive evaluation of the Taciuk Process, comparing the commercially used Hot Water Extraction Process with Flexicoking as the primary upgrading process. The Taciuk Process reduces capital cost, provides higher net revenue through increased product yield and provides an improved rate of return on total project capital investment.

Mined Oil Sand Plants Major Processing Steps



The Partec Lavalin Report Findings

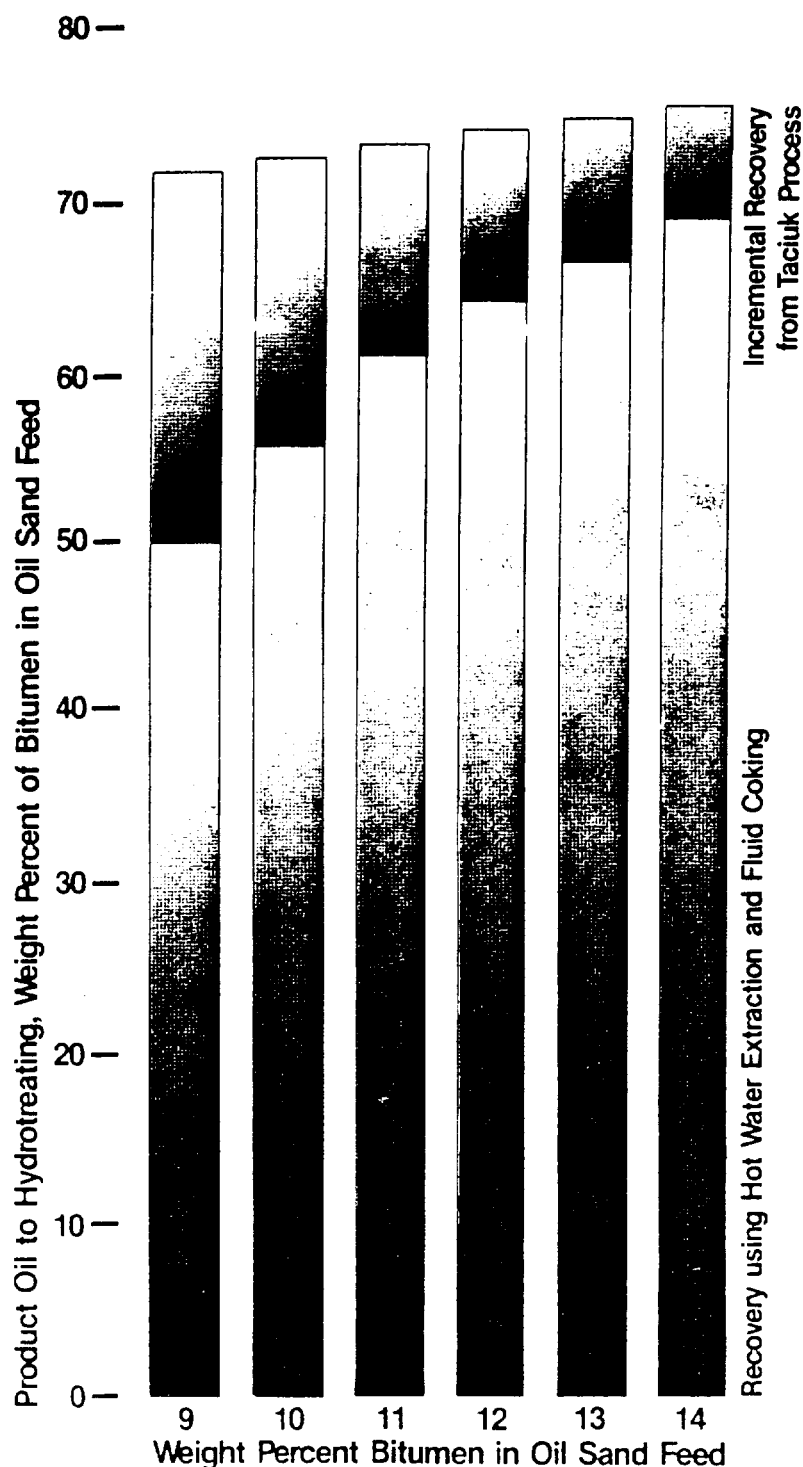
	22 Million Tons/Year Oil Sand Feed		78 Million Tons/Year Oil Sand Feed	
	HWE/ Flexicoking	Taciuk	HWE/ Flexicoking	Taciuk
Synthetic Crude Production, BPCD	30,015	33,689	106,418	119,417
Gross Annual Income, Million dollars	445	499	1,576	1,768
(NORP - 40.58 \$/Bbl)	41,475	33,326	34,824	30,489
Project Investment, \$/Daily Bbl Capacity	13.57	13.58	10.51	10.58
Operating Costs, \$/Bbl	24.2	32.5	31.4	36.6
Discounted Rate of Return, % (Excluding depreciation, income tax & Crown royalty)				

Feed basis: 11.6% bitumen content
Economic advantage will increase with lower
grade feeds.

The Potential

As you can see, substantially improved oil yields are projected for oil sands plants utilizing the Taciuk Processor. Of special interest is the relative insensitivity to oil sand feed grade variations. These yield improvements are the result of a major processing difference:

The Taciuk Processor applies heat directly to the oil sands. All oil in the feed sand is subjected to reaction



temperatures above 975 °F (524 °C). At these temperatures, oil must thermally crack, producing coke, light oil and off-gas. The light oil and off-gas are recovered, and most of the coke is consumed as fuel.

This process is not materially influenced by the fines (minerals less than 44 micron in size) contained in the oil sand feed.

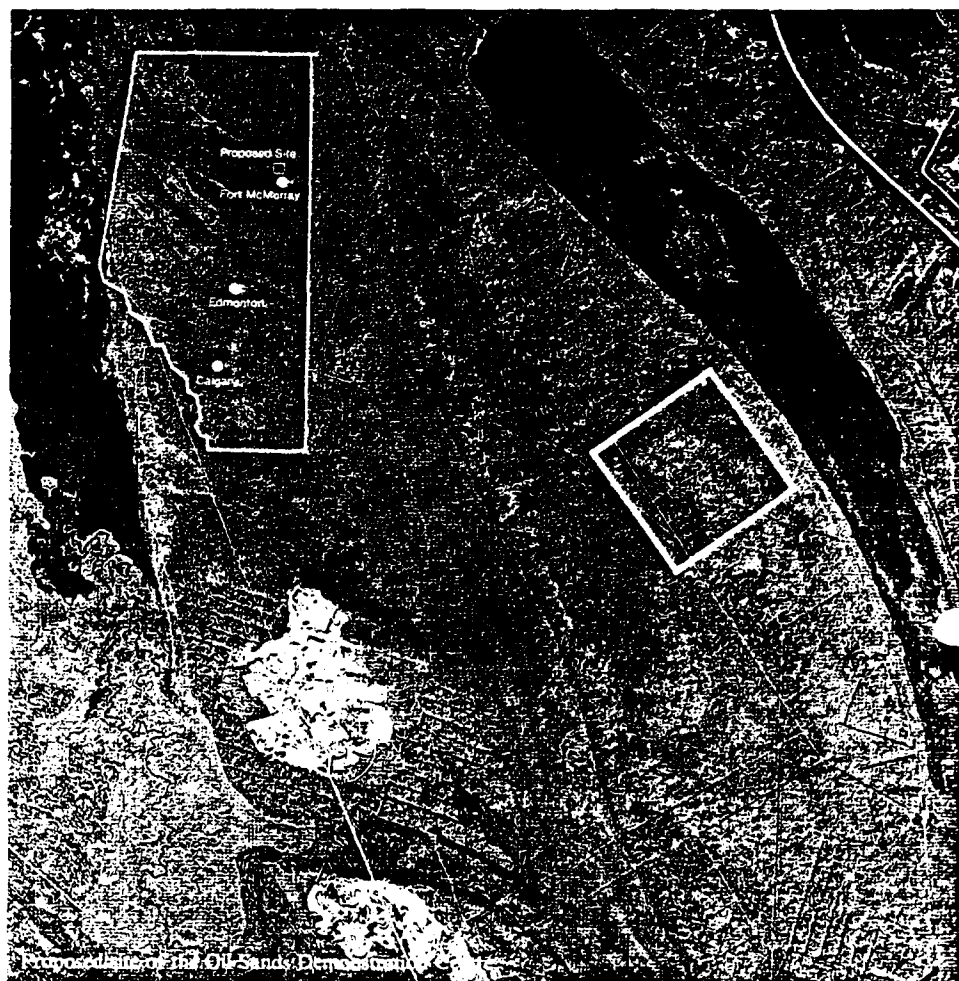
It is apparent that the Taciuk Process provides an effective alternative to Hot Water Extraction which relies on gravity separation to separate sand/oil/water so they may be handled separately. The fines content of oil sand feed interferes with this gravity separation and results in significant oil losses to the tailings ponds. In general, the fines content is inversely proportional to the bitumen contained in the oil sands. Increased fines content, as measured by reduced bitumen content, increases oil losses in the Hot Water Extraction Process.

The Demonstration Plant

It would be impractical to move directly into a commercially-sized facility from the Calgary Pilot Plant operation. The next logical phase of development is a large scale, semi-commercial, Demonstration Plant.

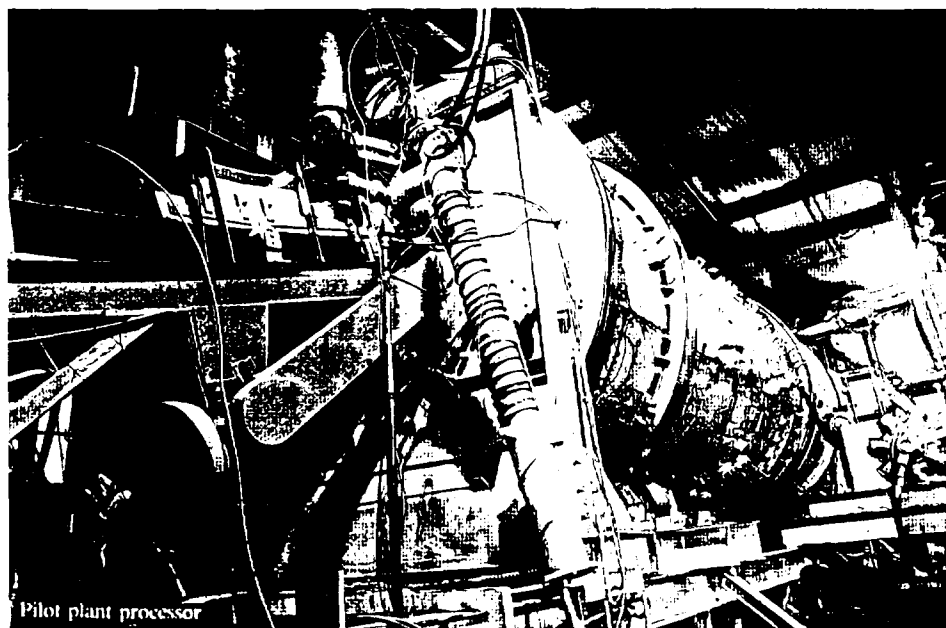
Results of the Calgary Pilot project, combined with specific small-scale tests of the Taciuk Processor, have provided valuable direction in determining parameters and methods for scaleup to larger capacities. Confirmation of the scaleup relationships, with adjustments where required, based on the performance of the Demonstration facility is essential. The Demonstration Plant, operated continuously over an extensive period of time on run-of-mine feed, will also provide information on:

- Process service factor
- Mechanical availability
- Process stability and flexibility with changing oil sand feed grade
- Equipment maintenance requirements
- Optimum operating procedures



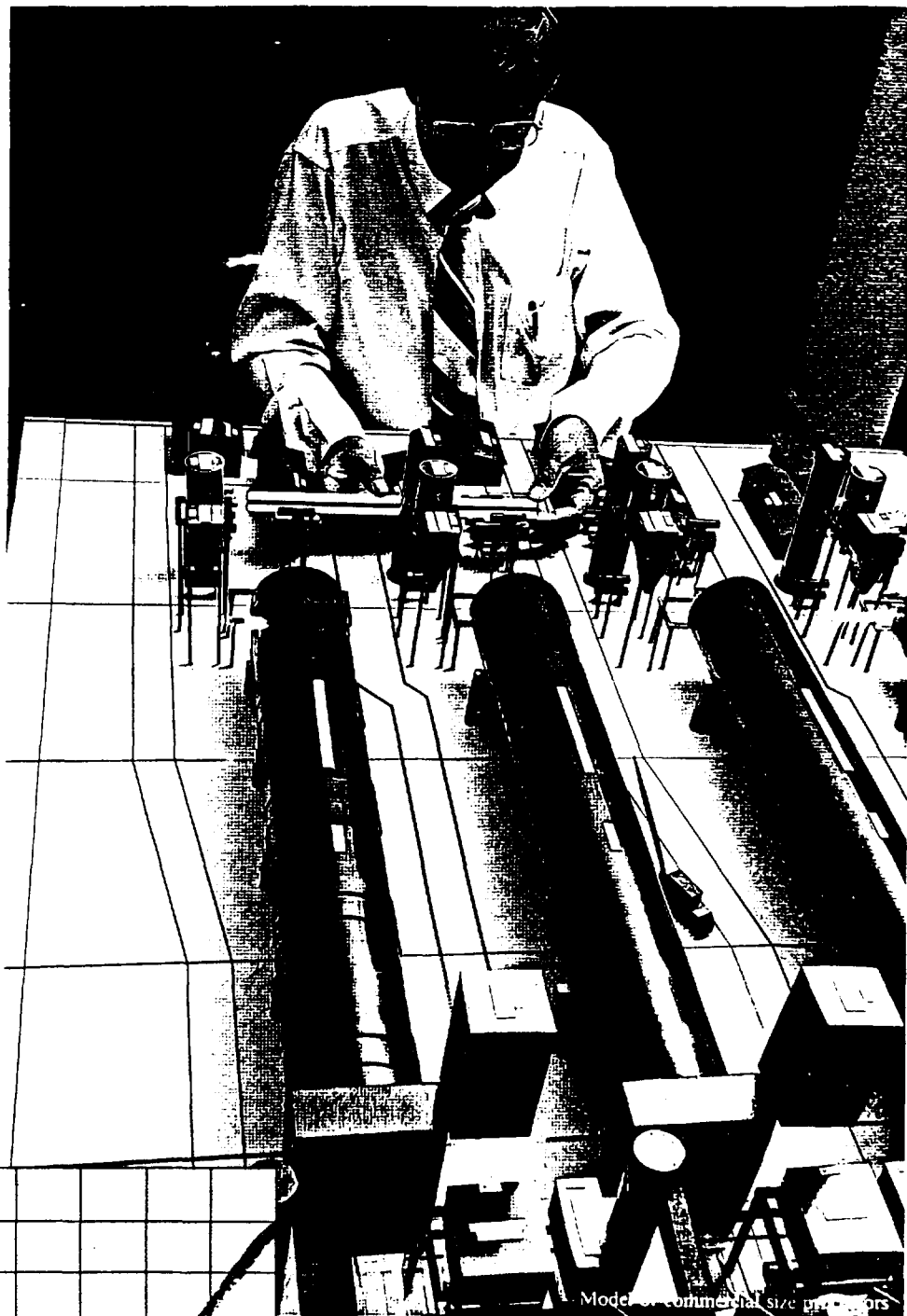
The Demonstration Plant must be large enough to adequately represent all process and mechanical aspects of a commercial operation. The capacity

of a single train commercial Processor will be of the order of 1000 tons/hour. Analysis of the conceptual commercial design established that the minimum acceptable capacity of the Demonstration facility is of the order of 100 tons/hour. Therefore, the proposed Demonstration program is based on the detailed design, construction and operation of a 100 tons/hour facility.

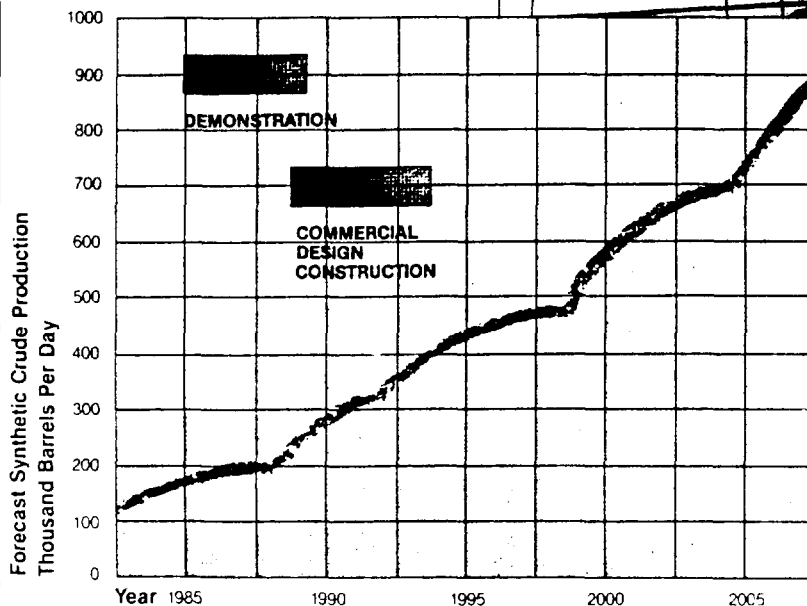


With the Demonstration facility at 100 tons/hour, scaleup from the 5 tons/hour Pilot Plant is 20:1. Scaleup to the 1000 tons/hour commercial capacity is 10:1. These scaleup ratios meet industry standards in scaling up from the Pilot Plant to the Demonstration Plant, and from the Demonstration Plant to commercial capacities.

The facility will be located on the site of the Oil Sands Demonstration Centre, south of the Syncrude Canada Ltd. mine, and will contain all the elements of a commercial Taciuk Processor.



The Alberta Energy Resources Conservation Board forecasts a significant expansion in synthetic crude oil production beginning about 1988. In order to have the Taciuk Process available as a candidate process for the forecasted increase, the Process must be demonstrated now.



The Partners

Over the next four years, the project will move forward with a two-year detailed design and construction period, followed by a two-year operation period. An execution plan, project schedule, and capital and operating cost estimates have been developed on this basis. The total estimated cost of the program is \$74.3 million.

AOSTRA has approved funding for 50 per cent of the Demonstration Plant phase. In keeping with our mandate to involve industry in the development of new technology, we are ready to be joined on an equity basis by industry members.

Based on the results of the pilot project and the commercial potential of the process, we are now confident in offering you the opportunity to become a partner in progress on the Taciuk Project.

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Project News
September 1986

UMA

Industrial Projects

Taciuk Processor Promising for oil shales

Calgary

UMATAC Industrial Processes, a division of UMA Engineering Ltd., advises that tests have been successfully completed on oil shales from the U.S.A., Australia and New Brunswick.

All of these materials processed well in a batch test unit. The U.S.A. high grade oil shales yielded 210 to 250 litres of oil per tonne, and average grade oil shales yielded 125 to 170 litres/tonne. The Australian oil shales yielded 140 to 150 litres/tonne of 30 to 33 API oil products.

The New Brunswick oil shales yielded 210 litres/tonne of feed.

In addition to testing the Taciuk Processor on oil shales, the Processor also appears to have promise for the treatment of waste dump materials. Samples of waste consisting of a mixture of water, acid, oil, carbon residues and various amounts of inert solids and soil particles were batch tested with promising results.

The Taciuk Processor is a new dry heat process developed by UMATAC Industrial Processes for extracting bitumen from the tarsands and oil from oil shales. It has been successfully tested in a pilot project near Calgary over the past seven years.

Design is now underway for a 90 tonne/hour demonstration plant to be constructed at the Athabasca tarsands area in Northern Alberta. Design and estimates have now been completed for the site infrastructure for this plant and a detailed analysis of the oil handling and off-gas treatment facilities has been completed.

Studies are now underway to evaluate alternative methods of handling and treating effluent flue gases. It is now anticipated that construction of the \$90 million project will be underway later this year or early 1986.



Model of commercial size Taciuk Processor

Computer aids design of Taciuk Processor

Calgary

The evolution of the design of the Taciuk Processor through bench, pilot, demonstration and commercial size has been substantially assisted by the use of computer modelling techniques.

A computer based Finite Element Analysis (FEA) has been used to complement empirical design work on the Taciuk Processor and to expand the number of design variations that were studied.

The FEA program on UMA's PRIME 750 computer was used to analyze the complex mechanical and thermal stresses in the various components of both the demonstration plant and the commercial scale Taciuk Processor.

The Taciuk Processor is similar in appearance to the rotating kiln. However, where it deviates from conventional technology is in its heavy internal concentric shell structure and variable thermal loadings. In order to evaluate the support and construction techniques for such a unique mechanical structure, scale models and computer modelling techniques were employed.

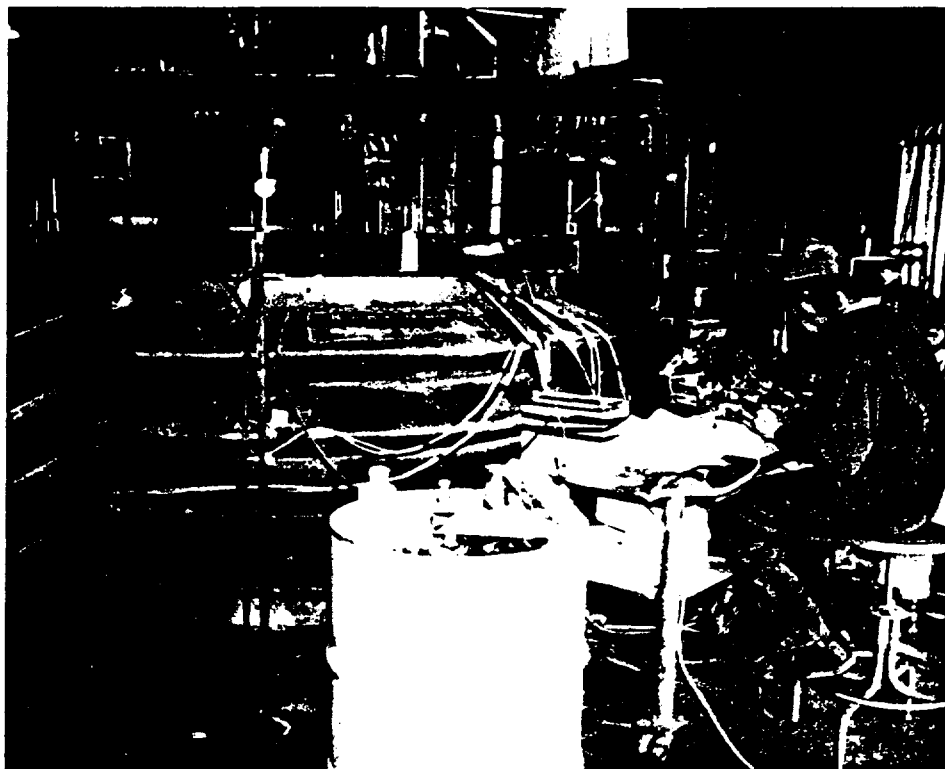
One model, a one-quarter scale cylindrical shell, was built to research internal structure support schemes. The instrumentation for this test unit comprised over 240 strain gauge elements and eight load cells coupled with a data logger to the PRIME computer. A data base program was written for storage of nearly 300,000 pieces of data. Other computer programs for calculations of stress and graphic display were developed to compress the information to a manageable size.

An important process design area of the Taciuk Processor is the counter-current heat exchange section where incoming oilsand is preheated by the existing hot tailing sand and flue gases. Using plain cylindrical shells, commercial size processors would be of enormous length and costs. To reduce the processor dimensions and costs, multiple inner shells with enhanced surfaces are being considered.

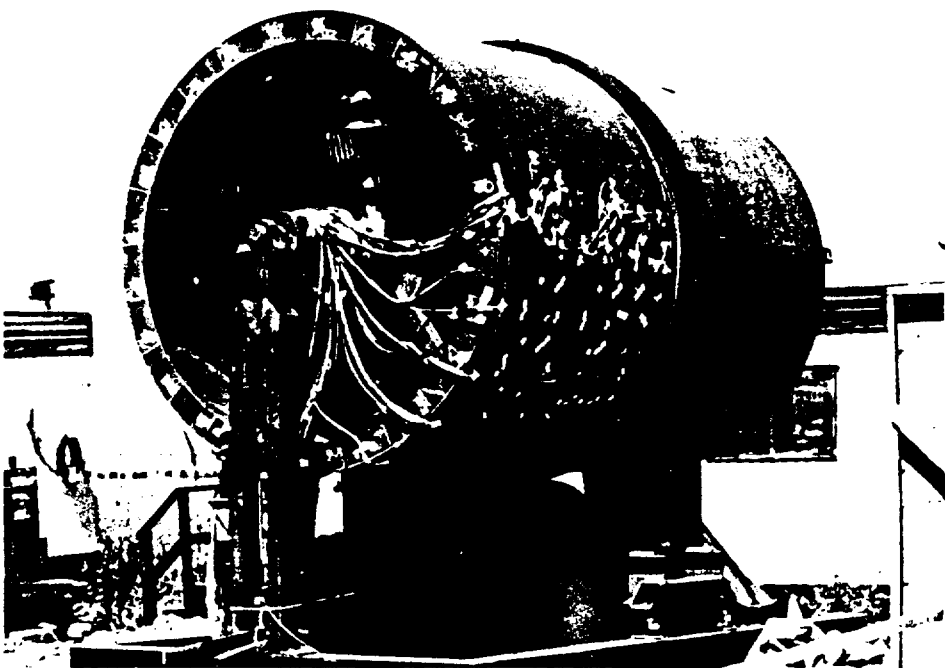
A second model, at full scale, was constructed to determine the strength characteristics of the corrugated shells. Two sizes of shells were used: each equipped with 40 strain gauge elements.

A batch heat exchange test program has been implemented to evaluate various configurations and other variables such as rotational speed and bed depth. The program consists of heating batch charges of sand in a rotating drum in a stationary furnace box. Temperatures are recorded by a datalogger and transmitted to the PRIME computer for storage and analysis.

Results from the batch heat exchange test program are necessary inputs to the computer model of the processor. Empirical work such



1/4 scale commercial processor stress test apparatus requiring over 240 strain gauges

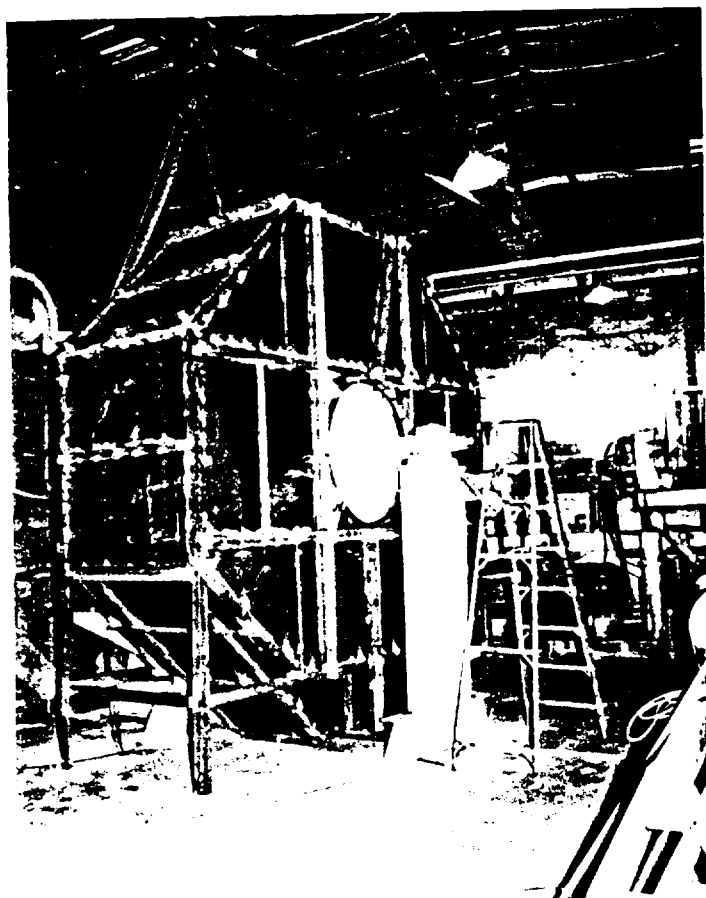


Full size 9' diameter corrugated stress test unit

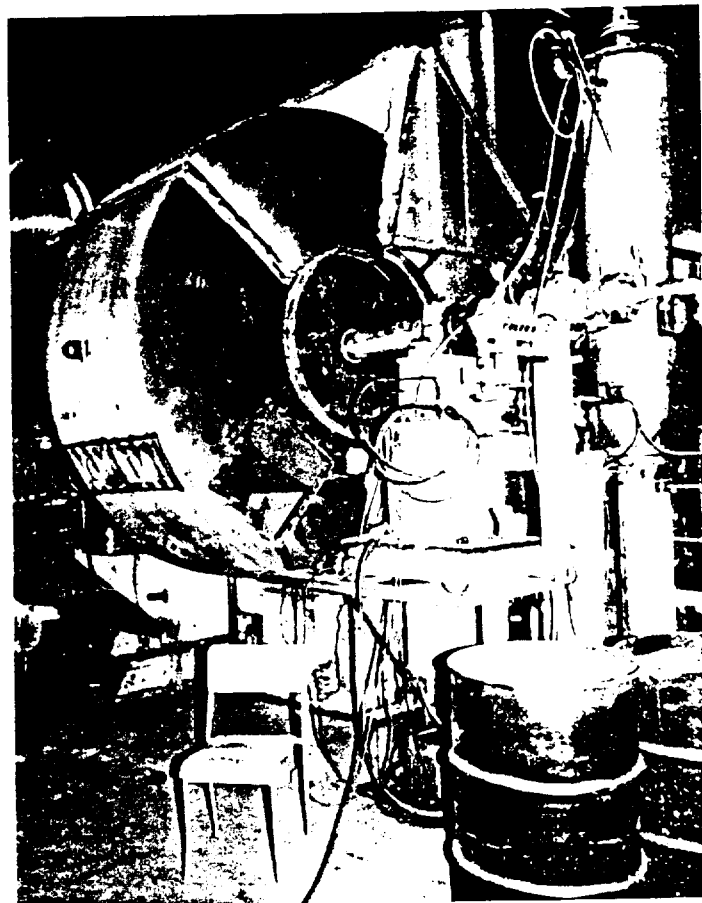
as this refines the mathematical relationships used for computer simulation of not only the heat exchange, but also coke combustion, pyrolysis of bitumen and material transportation.

At the pilot stage, the computer model assists in interpretation of results and in the optimal selection of different operating conditions. The model will also be used to establish reliable scale-up criteria.

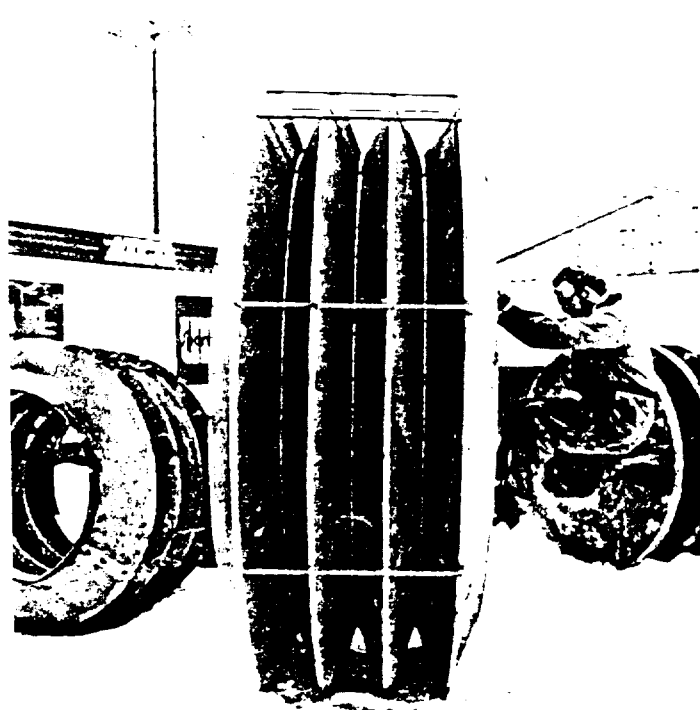
Industrial Projects



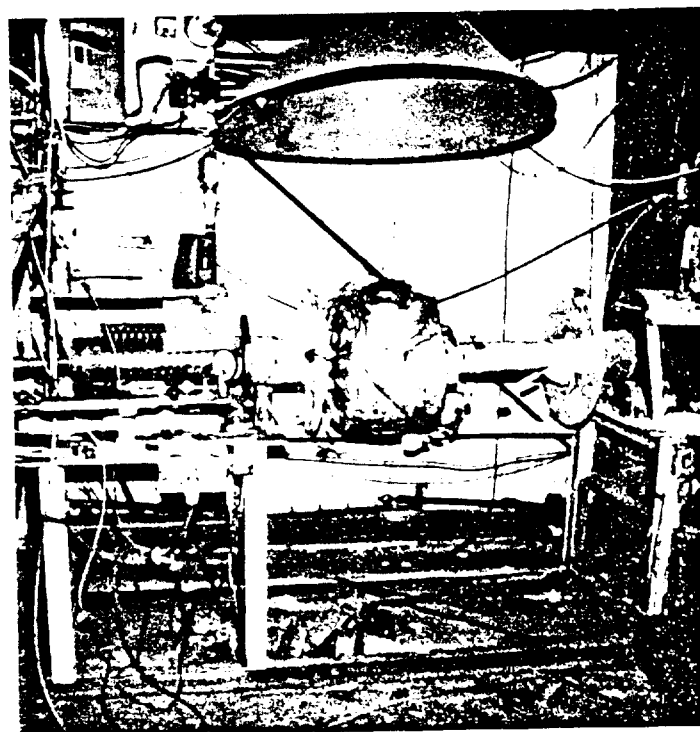
Furnace enclosure for the batch heat exchange test program



Opened furnace enclosure and mounted shell configuration



Various shell configurations for use in the batch heat exchange test program



4" x 12" diameter rotating batch test unit used for elevation of different feedstocks